AN ASSESSMENT OF THE DISTRIBUTION AND CONSERVATION STATUS OF ENDEMIC AND NEAR ENDEMIC PLANT SPECIES IN MAPUTALAND

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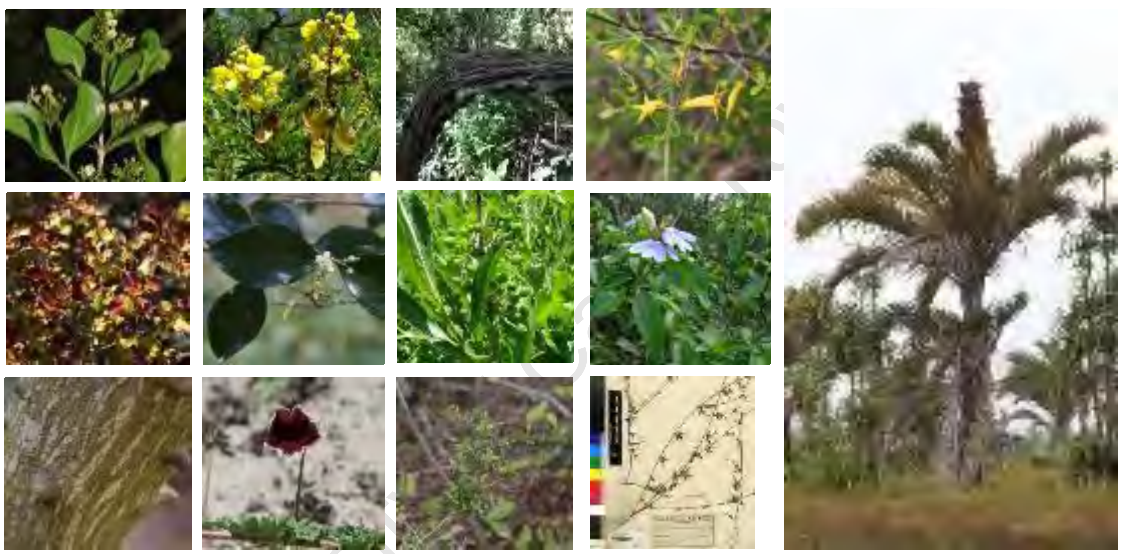

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PLAGIARISM DECLARATION

I know that plagiarism is wrong and declare that all documents that contributed to this study have been cited and referenced.

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ABSTRACT

The Maputaland Centre of Endemism (MCE), an area stretching from northern-east KwaZulu-Natal in South Africa to the Limpopo River in southern Mozambique, holds more than 2,500 native plant species. Of those, over 203 are endemic or near endemic to this area. However, the current high human population density in MCE, coupled with high population growth, has increased the pressure on the natural resources of the region and threatens the natural vegetation and plant diversity. Therefore, there is a pressing need to fully understand the threats faced by the Maputaland endemic and near endemic plants and to carry out appropriate conservation actions. In this context, the main aim of the study was to document the distribution of the MCE endemic plant species, with particular emphasis on southern Mozambique. The study also aimed to document the threats to these species and to assess their global conservation status using the International Union for Conservation of Nature (IUCN) Red List Categories and Criteria. This was done by gathering historical species distribution data from herbarium specimens and by assessing their current distribution in the field. In addition, a land cover data set was used to evaluate the level of habitat transformation over time. As a result, 13 endemics were assessed, 11 of these species for the first time. Of the 13 species assessed, two were assessed as Least Concern, five as Vulnerable, four Endangered, one Critically Endangered, and one possibly Extinct. MaxEnt models were used to model the potential distribution of the species assessed and to identify hotspots and priority areas for conservation. The priority areas represent sites of greatest overlap, where 50% of all modelled species overlap in their suitable potential distributions. With this approach, priority areas were identified that can be used in conservation planning, protected area expansion, or other conservation projects. This analysis showed that the highest number of the study species (>7) is concentrated within the Licuati Forest, located south of Maputo in Matutuine District, southern Mozambique. The main threat to this area is charcoal extraction and although none of the endemic species are targeted for charcoal production, the impact of the associated habitat destruction on the endemic species is expected to cause severe declines. It is recommended that studies on the dynamics of the Licuati Thicket vegetation are needed, particularly in terms of the impact of charcoal extraction on the endemics.

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1. INTRODUCTION

The Maputaland Centre of Endemism (MCE), which stretches from northern KwaZulu-Natal in South Africa to the Limpopo River in southern Mozambique, holds a high number of native plant species (>2,500) with more than 203 being of restricted range distribution (van Wyk 1996; van Wyk & Smith 2001). Despite its botanical richness, this remarkable biodiversity is threatened (Gaugris & van Rooyen 2008). The current high human population density in this area, coupled with the high population growth (Bruton 1980; Gaugris & van Rooyen 2008), has increased the pressure on natural resources, threatening the natural vegetation and plant diversity. The majority of the population in this area relies mainly on subsistence farming for sustaining livelihoods, which causes an increasing demand for land use and plant-based resources such as fuel-wood and building materials. In addition, the accelerating economic development through urbanization and industrial expansion results in further non-sustainable exploitation of natural resources. There is, therefore, a pressing need to fully understand the threats faced by Maputaland endemic plants and to carry out appropriate conservation actions.

A particular concern for the Maputaland area is deforestation resulting from wood cutting for charcoal production. In Mozambique, several studies (Drigo et al. 2008; Sitoe et al. 2012; Sitoe et al. 2013) found that there is a set of direct and indirect causes of deforestation. First, the direct causes include commercial farming, shifting land for subsistence farming, charcoal production, development of new infrastructure, and expansion of urban areas (Drigo et al. 2008; Sitoe et al. 2013). Charcoal production and collecting of fire-wood have been identified to have a significant impact on areas close to cities such as Maputo, Matola, Beira and Nampula (Sitoe et al. 2013). Second, indirect causes may include weak legislation, and lack of enforcement that then favors outsiders to impose their own rules concerning wood and charcoal extraction in order to fulfill their personal business interest within the forest sector (Sitoe et al. 2013).

1.1 Assessing the conservation status of selected Maputaland endemic plant species

With increasing biodiversity loss throughout the world (CBD 2010), it is considered important to assess the conservation status of as many species as possible against the International Union for Conservation of Nature (IUCN) Red List (RL) Categories and Criteria (Callmander et al. 2005). The IUCN RL Criteria have gone through several improvements (Mace & Lande 1991; Mace et al. 1992; Gardenfors et al. 2001) to reach international recognition (Akçakaya et al. 2000).

Therefore, the revised Criteria of the IUCN RL are less subjective than earlier versions and provide a useful tool to assess the conservation status of species across the world (Rodrigues et al. 2006). The information resulting from the assessments provides an important contribution towards enabling rapid and informed decisions on what and where to place conservation efforts (Bachman et al. 2011). Moreover, the information from the Red List is useful, for example, as a guide for better management of natural resources both locally and globally (Akçakaya et al. 2000; Rodrigues et al. 2006; Wulff et al. 2013). Red List assessments influence decisions on how to use the land through the environmental impact assessment (EIA) process. They also influence the establishment of many different agreements such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which regulates the trade of species (Collar 1996; Rodrigues et al. 2006; Neil et al. 2008). However, for areas where baseline population occurrence data have not been extensively collected it is difficult to conduct conservation assessments due to the lack of essential information such as the abundance of the species, the size of populations as well as the quality of the habitat (Callmander et al. 2010; Wulff et al. 2013). This is the case for the Maputaland endemic or near endemic plant species within southern Mozambique where data on population size and trends are not readily available. Therefore, the present study targeted the MCE endemic and near endemic species in order to accumulate, for the first time, information on the distribution and abundance of species.

Currently, Mozambique has about 5,781 known plant species (MICOA 2014). The first Red Data List for the country was published in 2002 under the auspices of the Southern African Botanical Diversity Network (SABONET) project and it contained 300 species (Izidine et al. 2004, MICOA 2009). Additional assessments have been conducted as part of the Darwin Initiative and the ProNatura-Paris Museum “Our Planet Reviewed” projects. The projects aimed to survey the high altitude vegetation and the coastal dry forest in northern Mozambique respectively. The contribution of the two projects to the IUCN Red List was 20 and 31 species respectively (MICOA 2014). With these assessments, the number of Mozambican plants assessed has increased to 351. This figure shows, however, that only 6.1% of the known plant species have been assessed against the IUCN Red List Categories and Criteria.

Mozambique, being a signatory of the United Nations (UN) Convention on Biological Diversity (CBD) has obligations towards reducing biodiversity loss. The Aichi biodiversity target number

12 states that by 2020 actions will have been taken towards assessing the conservation status and preventing extinction of known threatened species (www.cbd.int/sp/targets/). In addition to the Aichi targets, all CBD members including Mozambique have to meet targets such as number two and seven of the Global Strategy for Plant Conservation (GSPC). These targets encourage assessments of the conservation status of the majority of known plant species in order to assist conservation decisions, and to conserve as many species as possible within their natural habitat (CBD 2012).

1.2 Rationale and objectives

Given that resources are scarce, support for conservation action requires cautious and well-targeted approaches. This calls for prioritization to ensure that resources are used efficiently in conservation programs (Sanderson et al. 2002). Thus, the establishment of conservation priorities, in light of environmental degradation, requires sound knowledge of the distribution of plant biodiversity (Rodrigues et al. 2006; Wulff et al. 2013). In this context, the main objective of the study was first to document the distribution of the MCE endemic plant species, with greater emphasis on southern Mozambique. A second objective was to identify the population sizes and threats to these species as well as to assess their global conservation status using the IUCN Red List criteria (IUCN 2012). A third objective was to model the potential distribution of the species using Maximum Entropy Models (MaxEnt) and then identify priority areas for conservation based on the overlapping potential distributions of and threats to the studied species. Therefore, the study addressed the following key research questions:

1. What is the spatial distribution of the Maputaland endemic and near endemic plant species, and where are they concentrated (potential hotspots)?
2. What are the major threats to the Maputaland endemic and near endemic plant species and what is the global conservation status of each species?
3. Based on the potential distribution of the endemic species, where are the priority areas that, if protected, would most benefit the conservation of the MCE endemic plant species?

2. METHODS

2.1. Study area

The Maputaland Centre of Endemism (MCE) as defined by van Wyk (1996) is an area of about 26,734 km^2 stretching from southern Mozambique to eastern Swaziland and northeast KwaZulu-Natal (Figure 1). The area is bordered by the Limpopo River (in Mozambique) to the north, by the Indian Ocean to the east, by the western foothills of the Lebombo Mountains to the west and by the St Lucia Estuary to the south (van Wyk 1996; van Wyk & Smith 2001). The MCE is an almost completely flat, low-level coastal plain with a maximum altitude of about 150 m, except for the Lebombo Mountains which reach about 600 m of altitude (van Wyk 1996; van Wyk & Smith 2001).

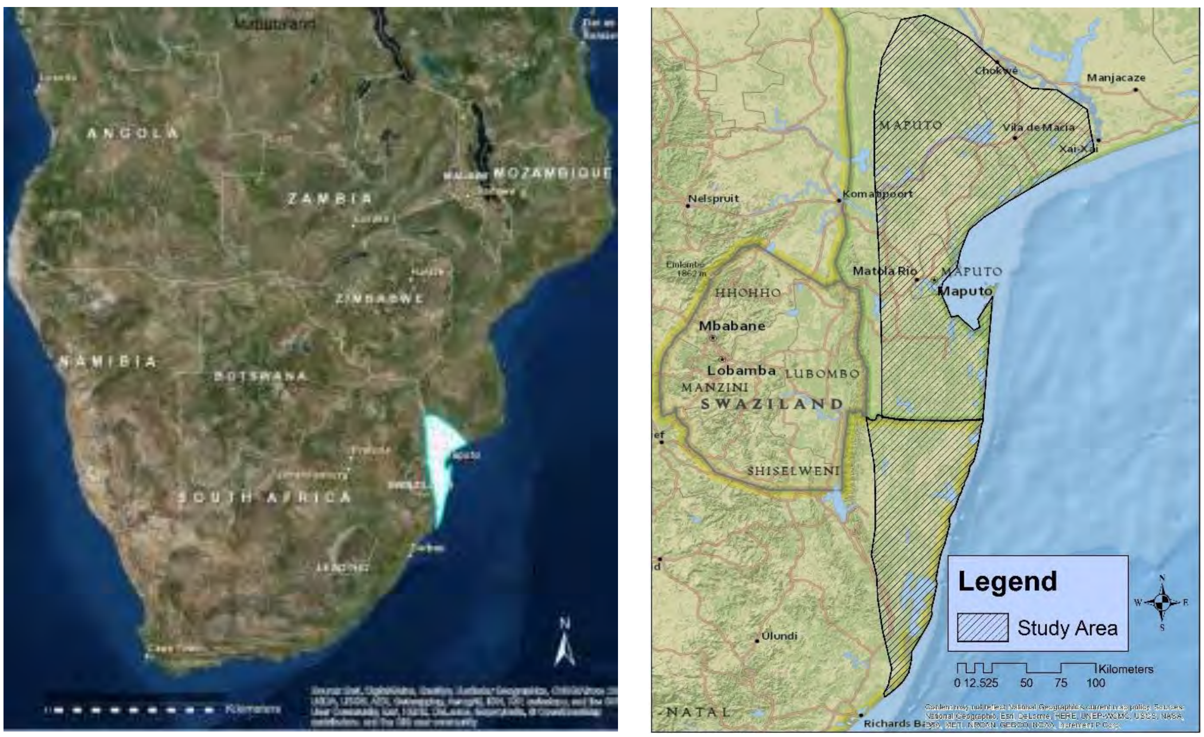


Figure 1: Map of the Maputaland Centre of Endemism as defined by van Wyk (1996) on the left. The study area o the right.

This project surveyed plant species that are endemic to the MCE and are concentrated within the coastal plain. Therefore, even though the MCE includes the Lebombo Mountains, the study focused on the low-lying coastal plain in order to cover the two major habitat types of the area, namely, sand forest and woody grassland. The coastal plain of the MCE extends from southern Mozambique as far as northern KwaZulu-Natal in South Africa. As northern KwaZulu-Natal has historically been well-collected, field surveys for this study were concentrated in the portion of the MCE which lies within southern Mozambique (Figure 1). Geologically, the coastal plain consists of Cretaceous to recent marine sediments of the Pleistocene era with the youngest dunes formed about 30,000 to 10,000 years ago (van Wyk 1996; van Wyk & Smith 2001). The soils of the coastal plain are infertile, consisting of recent, fine-grained aeolian sands, although some clay-rich alluvial soils are found along the floodplains of some larger rivers.

2.2. Vegetation of the study area

The vegetation of the MCE is characterised by forest and woody grassland along the coastal plain (van Wyk 1996, van Wyk & Smith, 2001, Izidine et al. 2003). The forest vegetation occurs on dunes of recent and ancient formation and it comprises patches of dry coastal forest, and thicket. In addition, the MCE vegetation includes relatively extensive areas of grassland, and swamps.

2.3. Data collection

2.3.1 Gathering historical data

The starting point was to review the taxonomic literature and the list of 203 endemic and near endemic plant species of the MCE compiled by van Wyk (1996). This list was examined using information contained within different taxonomic sources including nine volumes of the *Flora Zambesiaca*. Based on the most recent information about the distribution of the species and by excluding species endemic to the Lebombo Mountains, a new list of 22 coastal plain-restricted plant species was selected (see Appendix A). Of these, three species in three families are only known from the Mozambican side of the MCE (Rubiaceae: *Empogona maputensis*, Rutaceae: *Zanthoxylum delagoense* and Apocynaceae: *Emicocarpus fissifolius*).

More detailed information on the historical distribution of the study species throughout the MCE was collected from literature (see Appendix A) and herbarium specimens from the National Herbarium of Mozambique (LMA) and the Eduardo Mondlane University Herbarium (LMU) in Mozambique. Additional data were gathered from the following herbaria: the Buffelskloof Nature Reserve Herbarium (BNRH), the Pretoria National Herbarium (PRE), the Moss Herbarium of the University of the Witwatersrand (J) in South Africa, and the Herbarium at the Royal Botanic Gardens, Kew (K) in the United Kingdom. In addition, online data from the Global Biodiversity

Information Facility (GBIF) was assessed. GBIF data was not, however, included to any significant extent as several inconsistences in the georeferenced points were found.

Numerous herbarium specimens consulted for this study did not have geographical coordinates on the labels. Google Earth was used to georeference 425 specimens collected from the 1800s to the late 1990s. This was done by placing a place mark in Google Earth based on the description notes about the locality on the label of the specimen, and subsequently recording the coordinates given by Google Earth.

2.3.2 Sampling current occurrence of the study species in the field

Data collection in the field was divided into two phases, adding up to a total of 40 days. The first phase, of 15 days, took place in January 2015. The second phase which took place in October 2015, lasted for 25 days. The total distance covered during field sampling in northern KwaZulu-Natal and southern Mozambique was 7,000 km.

Fieldwork focused on collecting plant specimens based on their historical distribution from records accessed in the above herbaria. During the field survey, new localities were also recorded and herbarium specimens collected. Each collection was given geographical coordinates using a Geographical Positioning System (GPS) device. The collecting strategy followed Timberlake et al. (2009) by using a random walk and drive through accessible areas to gather as much data as possible on fertile identifiable material, from the full range of accessible habitats. In addition, the vegetation of the area where specimens were collected was noted. Various habitat and species-specific threats were documented, such as signs of charcoal production, cutting for fuel wood, timber and building material, expansion of farming, establishment of new roads, human settlement and urban and industrial development. The size of the populations of endemic species was estimated through counting individuals along transects and then extrapolating the number of individuals found per unit area to the total area of available habitat. The two different field trips conducted at different times of the year (early in the growing season (October), and in the middle of the growing season (January)), ensured that endemic species flowering at different times could be collected. The two fieldtrips also allowed time for different parts of Southern Mozambique to be sampled.

2.3.3 Processing specimen data

The plant specimens that were collected, were given a collecting number, pressed and dried in the field. The specimens were taken to the LMA herbarium in Maputo for final drying and then sorted into three groups for distribution in two local herbaria (LMA and LMU) and one herbarium in South Africa (the BNRH). Pre-identification was done in the field. Thereafter, at the LMA in Maputo, the specimens were identified to species level by following taxonomic keys, and confirmed by comparison of newly identified material to older material kept in the herbarium. Later, a final confirmation was done at the BNRH. Subsequently, a list of geographical distribution coordinates was compiled for each species based on georeferenced herbaria collections and those of the author from fieldwork during the course of this project.

2.4 Assessing conservation status under the IUCN categories and criteria

Conservation status was assessed for a total of 13 species (Table 1). The 13 species, out of 22 included in this study, represented those with sufficient historical and current baseline information to conduct an assessment. The assessments were carried out using the IUCN version 3.1 criteria (IUCN 2012). The species were assessed against all five quantitative criteria of the IUCN (A – declining populations, B – geographic range size, and fragmentation, decline or fluctuations, C – small population size, and fragmentation, D – very small population or very restricted distribution, E – quantitative analysis of extinction risk) (IUCN 2012).

Data on the distribution of the species were used based on field observations combined with historic specimen data. Modelled distributions were not used for the assessments. The information on the distribution of the species included Extent of Occurrence (EOO), Area of Occupancy (AOO), number of subpopulations and number of locations. The EOO is a parameter that measures the size of the species geographic range but includes both suitable and unsuitable habitat (Willis et al. 2003; Bachman et al. 2011). It is determined by a convex polygon in which all internal angles are not more than 180º and it encloses all points of the species occurrence (Willis et al. 2003; Bachman et al. 2011). The AOO accounts solely for the area that the species occupies. This parameter is considered to be the most appropriate for herbarium data because it represents only places where the species is present (Willis et al. 2003).

EOO and AOO were calculated using Geospatial Conservation Assessment Tool (GeoCAT) (see http://geocat.kew.org/). GeoCAT uses GPS points of species occurrence (Bachman et al. 2011).

A csv file of the points was uploaded to this online program in order to calculate the Red List parameters on the geographic distribution of each species. GeoCat calculated four parameters (EOO, AOO, number of subpopulations and number of localities). For this study, only EOO and AOO calculation were used as expert knowledge of each species, its dispersal abilities and response to threats were used to identify the number of locations and subpopulations where it is found, in accordance with the IUCN Red List Guidelines (IUCN 2012; IUCN SPS 2014).

2.5 Assessment of the threats to MCE endemic and near endemic species

Three approaches were used to assess the major threats to the MCE endemic and near endemic plant species.

2.5.1 Field observations of the threat to the study species

Detailed observations and representative photographs of the major threats and impacts to the study species and their habitats were recorded in the field. Particular attention was paid to the impact of charcoal production in southern Mozambique since this emerged early on in the study as an important potential threat to the study species and the region as a whole. During a three day period in October 2015 the number of bags of charcoal on the side of the main routes around the Licuati Forest Reserve was counted and GPS co-ordinates recorded for each location. Illustrations of the threat were also sourced from Google Earth images and represent locations that were visited and documented in 2015.

2.5.2 Analysis of the forest cover changes for the period from 2000 to 2014

The extent of forest cover in 2000 and area of forest cover loss for the period 2000-2014 was estimated using the data from the global forest change website (http://www.globalforestwatch.org/). The vegetation cover taller than 5 m was estimated based on time-series Landsat image analysis and was available as georeferenced raster images from the website. The layers which contained tree canopy cover for year 2000 (treecover2000) and forest cover loss between 2000 and 2014 (loss) encompassing the study site were downloaded for analysis. In this study, the area which contained vegetation cover greater than 25% vegetation was defined as forest. This threshold was determined by overlaying the extracted forest area in each of the layers onto Google Earth. The area showing more than 25% in the 2000 layer was extracted and the forest extent at year 2000 was estimated by counting the number of pixels. The same process was repeated for the loss layer to compute forest loss in the past 15 years. From these analyses the extent of the forest loss and its rate were estimated. All the analysis was done using QGIS.

2.5.3 Land cover (in 2013/2014) as a proxy for the assessment of land use impacts in MCE

The way in which land is used is an important consideration for conservation planning. Because of this the extent of different land cover classes within the MCE was determined. Land cover data was sourced from GEOTERRA IMAGE (Pty) Ltd. for the year 2013/14. The analysis was undertaken through the use of zonal statistics as a table tool in ArcMap Spatial Analyst extension.

2.5 Species distribution modelling

Species distribution models (SDM) were created for each endemic taxon, using Maximum Entropy Models (MaxEnt). The model algorithm in this program, mathematically equivalent to a General Linear Model (GLM), predicts the environmental suitability for a species and the likelihood of its occurrence in suitable habitat as a function of given environmental variables throughout the study area (Phillips et al. 2006; Wulff et al. 2013). This model is appropriate for using presence-only data (Merow et al. 2013), which is convenient for poorly-studied tropical regions (Phillips et al. 2006), like Mozambique, where absence data on plant species is not available.

To run the MaxEnt algorithm, it is necessary to provide topographic, climatic and substrate related environmental variables that are thought to be directly or indirectly related to the distribution of plant species (Wulff et al. 2013). Soil variables were included (Elith et al. 2011) due to the hypothesized importance of substrates shaping the distribution of the plant communities within the study area (van Wyk 1996). Topographic data was obtained or derived from the SRTM 90 m Digital Elevation Database v4.1 (Jarvis et al. 2008) and used to derive other datasets such as solar irradiation, hill shading, slope, etc. With respect to climatic variables, these were obtained from the Bioclim bioclimatic variables (Table 1) that are frequently used in SDMs. The bioclimatic variables represent annual trends (e.g. mean annual temperature, annual precipitation), seasonality (e.g. annual range in temperature and precipitation) and extreme or limiting environmental factors (e.g. temperature of the coldest and warmest month, and precipitation of the wet and dry quarters) and forms part of the WorldClim database (Hijmans et al. 2005; http://www.worldclim.org/).

Table 1: List of Bioclimatic and environmental variables that were used to build the SDMs using MaxEnt.

Code	Description
BIO1	Annual Mean Temperature
BIO2	Mean Diurnal Range (Mean of monthly (max temp - min temp)
BIO3	Isothermality (BIO2/BIO7) (* 100)
BIO4	Temperature Seasonality (standard deviation *100)
BIO5	Max Temperature of Warmest Month
BIO6	Min Temperature of Coldest Month
BIO7	Temperature Annual Range (BIO5-BIO6)
BIO8	Mean Temperature of Wettest Quarter
BIO9	Mean Temperature of Driest Quarter
BIO10	Mean Temperature of Warmest Quarter
BIO11	Mean Temperature of Coldest Quarter
BIO12	Annual Precipitation
BIO13	Precipitation of Wettest Month
BIO14	Precipitation of Driest Month
BIO15	Precipitation Seasonality (Coefficient of Variation)
BIO16	Precipitation of Wettest Quarter
BIO17	Precipitation of Driest Quarter
BIO18	Precipitation of Warmest Quarter
BIO19	Precipitation of Coldest Quarter; Altitude; MODIS NDVI for July 2005; Topographic Positional Index
Soil Type	Five soil variables

Given the availability of a wide range of environmental (including climatic) variables, the inclusion of correlated environmental variables (covariates) within SDMs is not advised as this can lead to over-fitted models with limited use (Kriticos et al. 2012). Hence, all 26 environmental variables were included within Principal Component Analysis (PCA; ESRI 2015a) to identify and extract the first 10 PCA axes that are uncorrelated and which account for more than 95% of the variation observed within all environmental variables considered. However, the use of PCA in SDM has a few limitations, but none relevant to this study. For example, the interpretation of models built using the PCA axes as variables cannot be used for climate change studies. Nor can the SDM models that are based on PCA axes easily be interpreted, as the input environmental variables are all transformed into a new multivariate attribute space (Kriticos et al. 2012). To interpret which environmental variables informed the new PCA axes, Band Statistics was used to assess the correlation between each environmental variable and all 10 PCA axes. For example, PCA axis 2 was strongly correlated with altitude (0.989), annual mean temperature (-0.949), mean temperature warmest quarter (-0.948), mean temperature coldest quarter (-0.944). PCA axis 2 clearly represents a temperature derived axis and could therefore be interpreted as such when reviewing the outputs from the MaxEnt models. In this study, PCA and Band Statistics were run within the Spatial Analyst extension of the program ArcMap 10.3.1.

2.5.1 Running the SDM

The input files for the MaxEnt species distribution models included coordinates of locations where species have ever been recorded and are known to occur (Merrow et al. 2013). Therefore, presence-only data was used to inform the models, and thus a key assumption was that sampling was random and that detection probability was constant across sites in a defined landscape (Yackulic et al. 2012). Throughout this landscape, MaxEnt selects background locations to evaluate the correlation between coordinates of presence locations with the environmental conditions of the study sites at the minimum entropy (Elith et al. 2010). Overall the models were set to run with a maximum number of 10 000 background points. The number of iterations was set to 5000 in order to allow sufficient time for convergence, and each model was set to generate 15 replicates (Young et al. 2011). Apart from species occurrence coordinates, the input files representing the environmental variables were comprised of the first 10 PCA axes from the PCA analysis. A sufficient number of point localities had been sourced to model the potential distribution for 12 species out of the 13 species studied. It has been suggested that a minimum number of 10 to 30 points can provide high accuracy in model predictions (Pearson et al. 2007; Costa et al. 2010). The one species that was not modelled was the one classified as extinct, *Emicocarpus fissifolius*, (Table 1) for which insufficient distribution data was available.

2.5.2 Identifying areas of greatest species overlap

2.5.2.1 Classifying and reclassifying MaxEnt files

The MaxEnt species distribution models were then imported into ArcMap10.3.1 and overlaid to refine the boundaries of the MCE and to identify the core area within the MCE that would serve as a priority for other conservation initiatives. The logistic output of MaxEnt creates raster files that contain continuous values ranging from zero to one (0 - 1) to represent “habitat suitability” (Young et al. 2011). For each SDM, a cutoff value (or threshold) is selected to classify whether the habitat is suitable or not. The process of generating suitability maps for each species entailed first converting the averaged MaxEnt’s ASCII files into raster format. Each raster file was then classified into suitable and unsuitable habitat based on the 10^{th} percentile training presence logistic threshold value. A 10% minimum threshold was used as there were small errors in the dataset which arose from the georeferencing of old herbarium records. This meant that 90% of the data would be used to develop the model and define suitable habitat. If the spatial accuracy of the distribution records were better, then a different threshold value could have been used. Finally, the Reclassify tool in the Spatial Analyst was used to generate a binary raster for each species with a value of 1 for suitable habitat and 0 for unsuitable habitat.

2.5.2.2 Hotspots and priority areas analysis

To determine where the distribution of the MCE endemic species overlapped, and to develop what has been called a hotspot map, the number of times that the suitable habitat for each species overlapped with other species was calculated. As suitable habitat for each species equalled 1, the values could be summed using the raster calculator in ArcMap (spp1 + spp2 + spp3 + …. + spp12). The boundary for the MCE was determined from the overlapping suitable habitat raster where two or more endemic species overlapped in their distribution ranges (calculated at a pixel level). The output was converted to a polygon shapefile, with a 5 km buffer around each polygon. The size of each polygon was then calculated and all polygons less than 100 ha were deleted to clean the boundary. The refined MCE centre of endemism boundary was large enough to include at least 90% of the endemic plant species selected for this analysis. The area of greatest overlap, where 50% of all modelled species overlapped in their suitable distributions, was extracted from the summed values to create spatially-defined, priority areas for conservation. These priority areas are suitable for use in conservation planning, protected area expansion, or other conservation projects. The output was converted to a shapefile and polygons smaller than 50 ha were deleted.

3. RESULTS

3.1 The overall distribution of selected 13 endemic plant species based on herbarium data and the 2015 field survey findings

The historic distribution of the 13 species, based on herbarium data, showed that more specimens (297 records) have been collected in KwaZulu-Natal (Figure 2) than in southern Mozambique (127). Therefore, prior to this study there were 424 specimens available of the 13 study species. As a result of this study, 143 new specimens were collected summing to a total of 567 records. A further 322 locality records were documented using a GPS device during field work undertaken in 2015.

The study of the overall distribution of MCE endemic and near endemic plants starts from the St. Lucia Estuary in KwaZulu-Natal, South Africa in the south, and stretches northwards as far as Gaza Province in southern Mozambique. However, *Zanthoxylum delagoense*, the MCE near endemic, reaches its far northern limit in Pomene area, Inhambane Province in Southern Mozambique. The species are not evenly distributed throughout the area. The areas with the highest concentration of species include Licuati thicket (Lt), south of Maputo in Mozambique, through Tembe Elephant Park in KwaZulu-Natal and then southwards as far as the UMkhuze area.

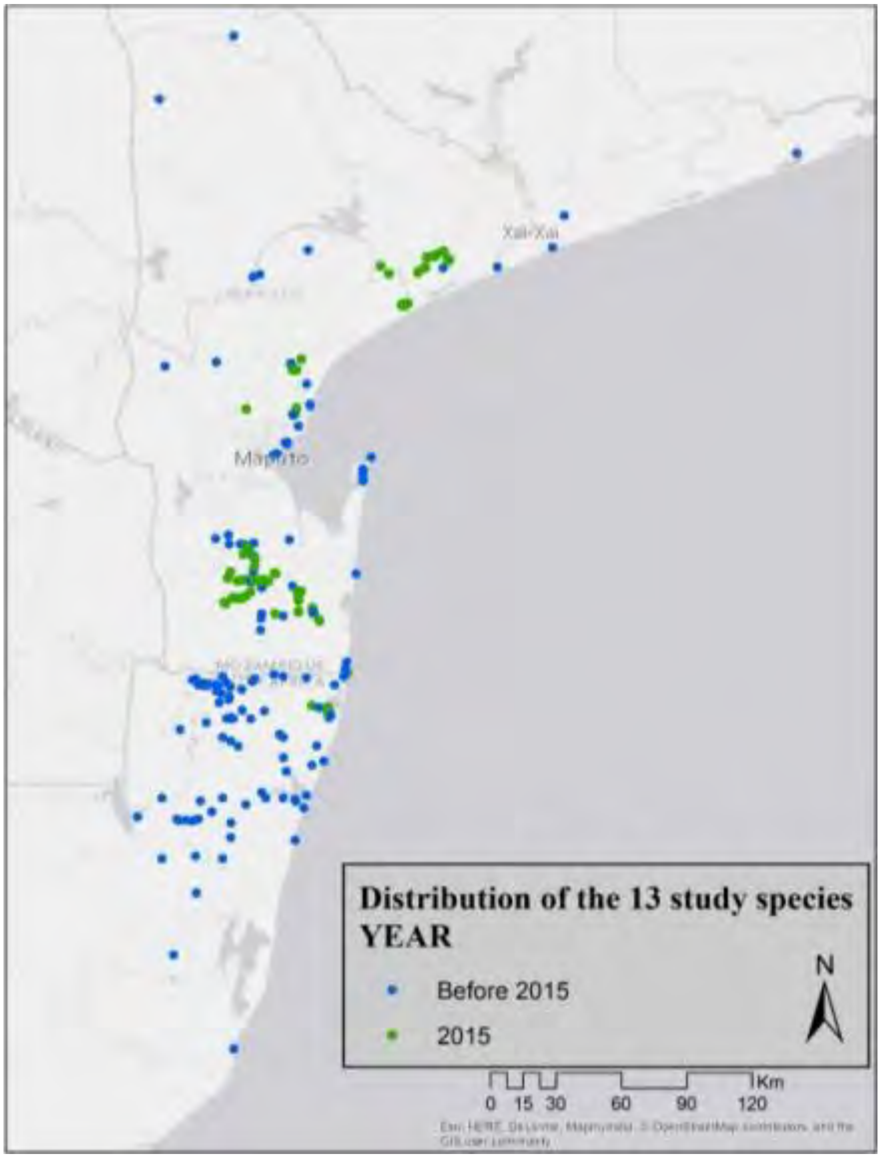
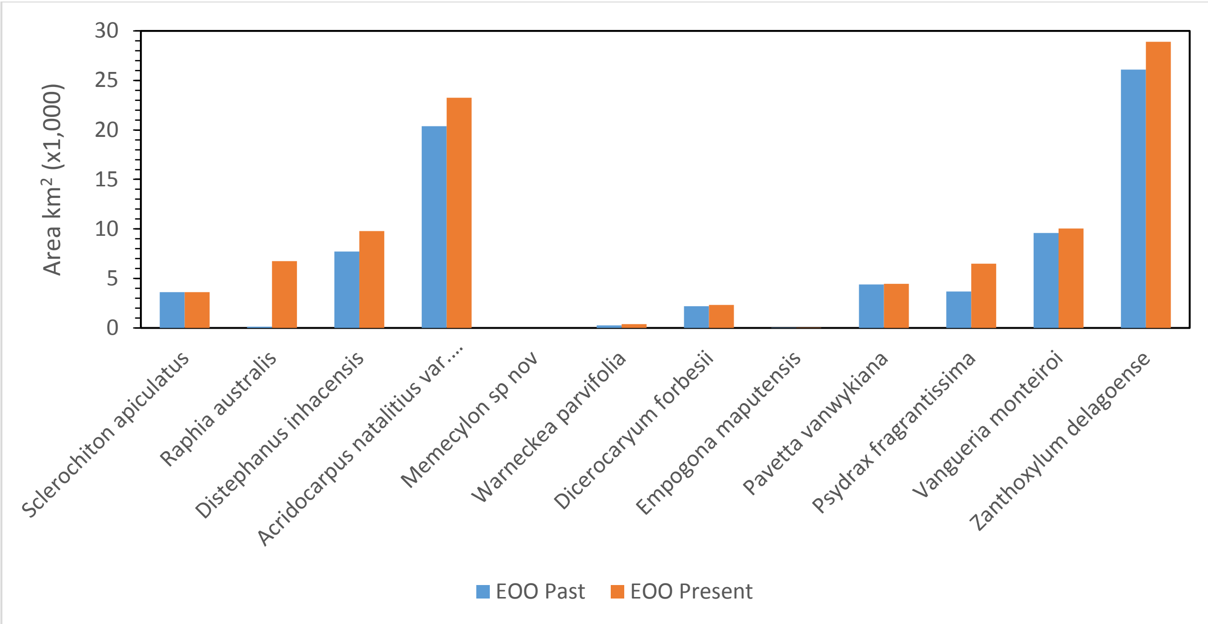


Figure 2: The overall distribution of the 13 MCE endemic and near endemic plants. The blue points show historic herbarium records and the green points are from fieldwork conducted as part of this study during 2015.

The information gathered under this study enabled accurate calculations of the IUCN parameters, Extent of Occurrence (EOO) and Area of Occupancy (AOO) (Figure 3) that are important for the Red Listing process. The average % increase in EOO and AOO values for all 12 extant species for which new occurrence records were gathered in this study were 18.6% and 33.6% respectively.



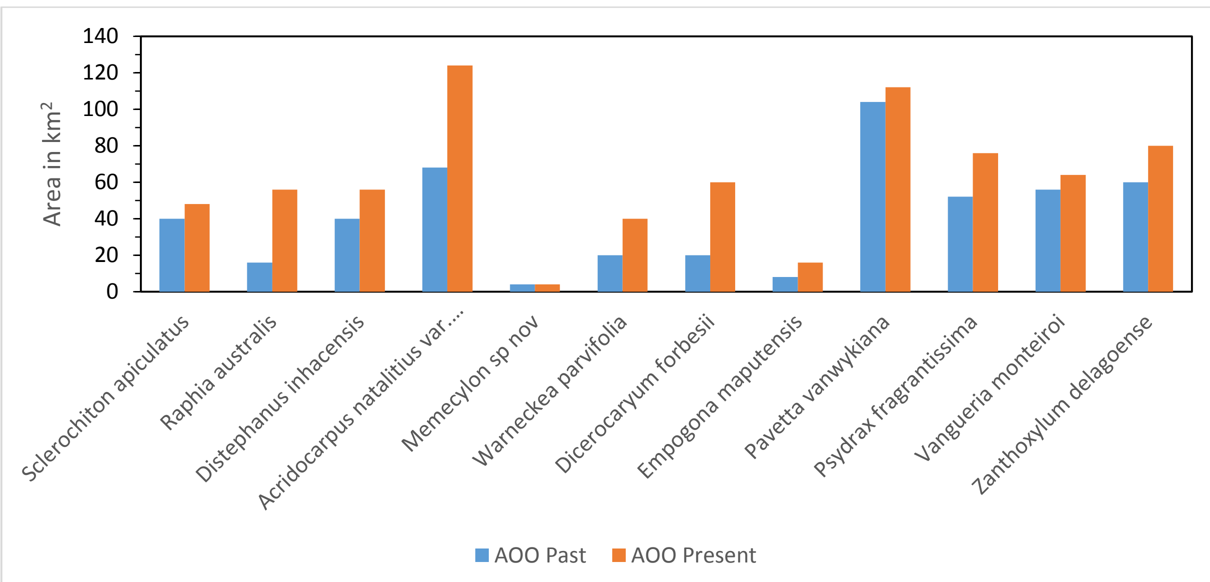


Figure 3: Known distribution parameters based on historical data from herbaria (EOO past and AOO past) and the additional data from this study (EOO present and AOO present).

3.2 The main threats to MCE endemic and near endemic plants

3.2.1 Field observations of the threat to the study species

The production of charcoal both for local consumption but increasingly for the generation of cash income in Maputo is one of the largest threats to the MCE endemic and near endemic plant species. This practice entails cutting thick woody stems, piling these stems on top of each other (Figure 4a), covering them with sand and grass (Figure 4b) and then setting them alight. In the process of cutting and cleaning large stems many small branches and twigs are left in the forest (Figure 4c).

These dry out and create a source of fuel for fire. The combination of a seasonal drought, with increased fuel from branches left during charcoal production as well as increased ignition sources from the lighting of charcoal kilns has resulted in increased fire frequencies occurring throughout forested areas of southern Mozambique, this was observed first hand at Licuati thicket (Figure 4d).

Figure 4: The primary pressure on forest habitat of southern Mozambique is production of charcoal. a) Thick woody stems that have been cut and piled for the production of charcoal, b) a charcoal kiln produced by covering cut logs with sand and grass to ensure slow burning, c) Dry old twigs resulted from preparing stems for charcoal, d) Depleted forest by fire from the charcoal production process, e – f) Bags of charcoal being sold on the main road from Boane to Bela Vista, Matutuine, south Maputo.

A total of 865 bags of charcoal stacked for collection or sale were counted over a three day period in October 2015 on the main routes around the Licuati forest (Figures 4e, 4f and 5) and over thousands on the main road to Maputo (Figure 5).

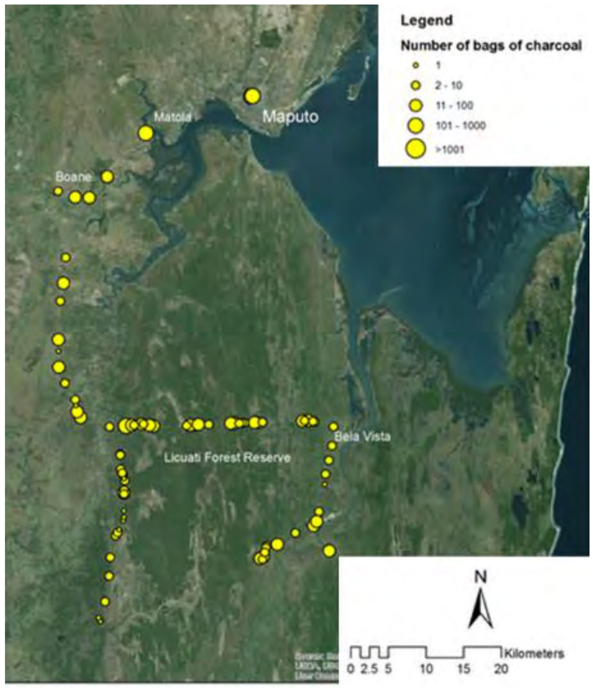


Figure 5. Locations of the number of bags of charcoal for sale or collection along the main routes around the Licuati Forest and on the main road to Maputo in October 2015.

The impact of charcoal production is further demonstrated by the series of Google Earth satellite images (Figure 6) which show the rapid change in vegetation for an example of the Licuati Forest Reserve over the last 12 years. No footpaths or tracks were present in 2004 in the forest when the first satellite image of the study area was sourced. Islands of larger trees such as *Newtonia hildebrandtii, Balanites maughamii* and *Afzelia quanzensis* remain undisturbed at this location. Nine years later in 2009 access roads have become evident in the satellite image and selective logging of large trees in the LFR is evident. In only two years and with greater access to previously impenetrable thicket, the cleared area has expanded significantly.

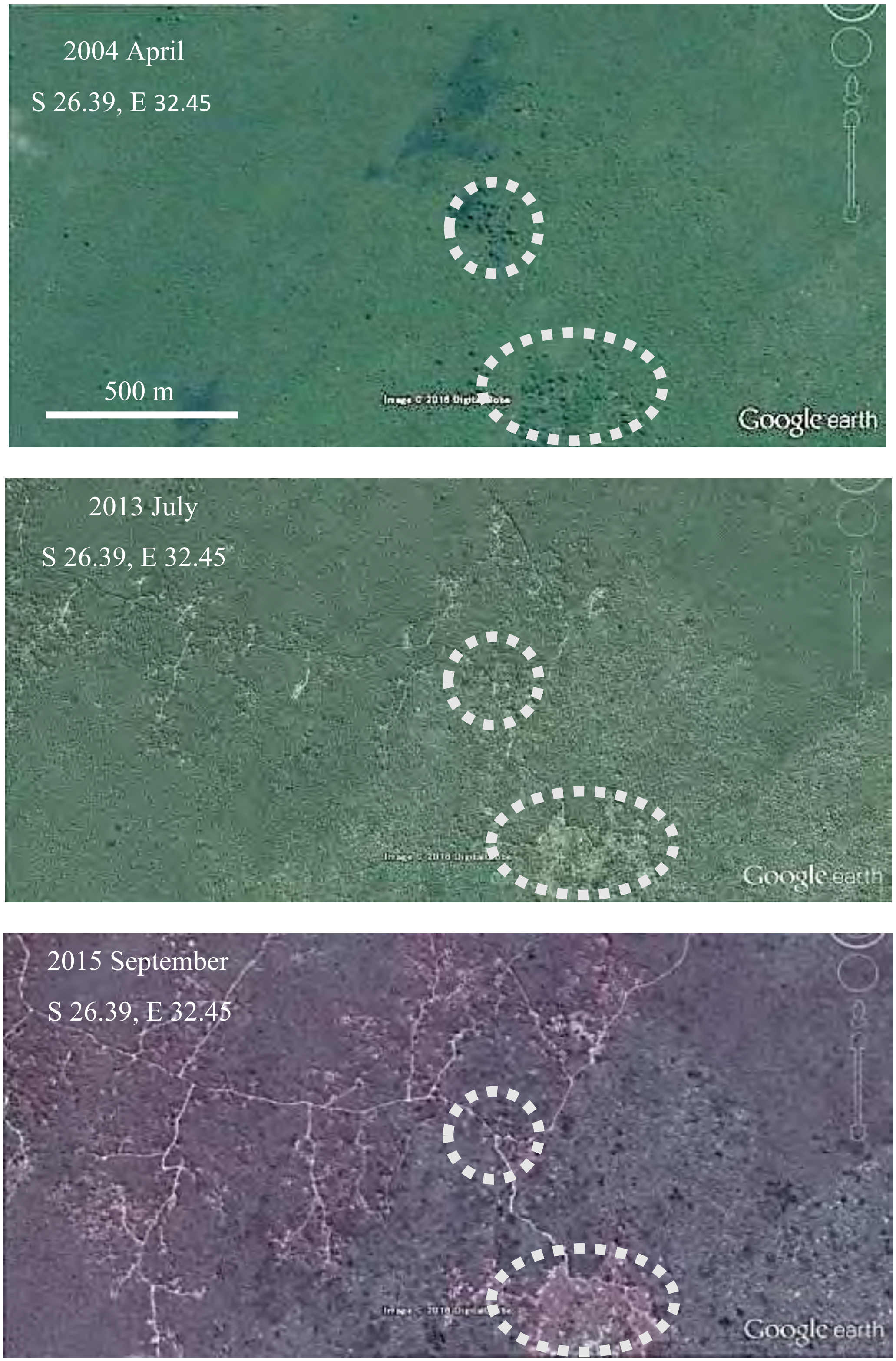


Figure 6: Degradation of forest in southern Mozambique, shown here for one site in the Licuati Forest Reserve. The images are from Google Earth and show (top) an intact forest without the presence of footpaths; (middle) the appearance of footpaths to select stands of large, targeted tree species (white circles); (bottom) extended path network and widespread clearing of thicket vegetation.

3.2.2 Analysis of the forest cover changes for the period from 2000 to 2014

Forest cover loss for the period 2000-2014 on the coastal plains of southern Mozambique and northern KwaZulu-Natal has been relatively high in both regions. Annual rates of loss are 0.55% for southern Mozambique and 0.96% for northern KZN (Table 2).

Table 2: Extent of forest cover in year 2000 and rate of loss for a period 2000-2014 based on satellite imagery analyses available from the global forest change website at http://www.globalforestwatch.org/

Area	Forest Extent in 2000 (km^2)	Forest extent in 2014 (km^2)	Forest cover loss (%)
Mozambique: southern coastal plain	5650	5181	8.3
KwaZulu-Natal: northern coastal plain	3787	3243	14.4
Total	9437	8424	10.7

3.2.3 Land cover (in 2013/2014) as a proxy for the assessment of land use impacts in MCE

The results from the analysis of land cover in the revised MCE (2 565 385 ha) showed that tree-dominated (44.1%) and tree-bush dominated (15.6%) vegetation together comprised nearly 60% of the area. Low vegetation and grassland also made up a large proportion of the area (34.5%) while water bodies (3.4%) cultivated lands (1.7%) and bare ground (0.6%) were relatively insignificant. The analysis was not able to differentiate between degraded and un-degraded forms within each cover class.

3.2.4 Summary of the main threats to the MCE endemic and near endemic plant species

Results from the field indicate that several human-related activities threaten the remaining populations of the MCE endemic and near endemic plants species. The most important of these are shown in Table 3 while further information may be found in Appendix B. Although the threats differ between species the loss and degradation of suitable habitat are the most important threats. Habitat loss occurs due to expansion of human settlement as well as from the development of commercial and subsistence agriculture in southern Mozambique. Degradation is resulting from the need of people who live in relatively close proximity to natural areas where the study species are found, relying on natural resources for their building purposes and for their energy needs.

Table 3: Summary of the main threats for each of the Maputaland endemic and near endemic plant species investigated in this study.

Family	**Species**	**Major threats**
Acanthaceae	*Sclerochiton apiculatus*	Habitat loss, human settlement, subsistence and large-scale farming, new infrastructural development, fire
Arecaceae	*Raphia australis*	Subsistence and commercial farming
Asteraceae	*Distephanus inhacensis*	Habitat loss due to intense exploitation of forestry resources, fire
Malpighiaceae	*Acridocarpus natalitius* var. *linearifolius*	Trade for medicinal use (roots), removal of habitat due to large scale food production, urbanization and industrialization
Melastomataceae	*Memecylon* sp nov.	Subsistence farming, charcoal extraction and fire
Melastomataceae	*Warneckea parvifolia*	Habitat degradation, charcoal production, fire, human settlement
Pedaliaceae	*Dicerocaryum forbesii*	Removal of habitat due to large scale food production, urbanization, and industrialization
Rubiaceae	*Empogana maputensis*	Habitat loss due to charcoal extraction, fire, subsistence farming,
Rubiaceae	*Pavetta vanwykiana*	Habitat loss due to human settlement, shifting agriculture, building of infrastructure.
Rubiaceae	*Psydrax fragrantissima*	Habitat degradation, charcoal production, fire, human settlement
Rubiaceae	*Vangueria monteiroi*	Habitat loss due to human settlement, commercial agriculture, afforestation,
Rutaceae	*Zanthoxylum delagoense*	Used for construction, human settlement

3.3 Conservation assessments for 13 species

The extensive observations and surveys conducted for each species in the field meant that it was possible to assess many under more than one of the IUCN criteria. The results of the conservation assessments show that 10 species (76.9%) (Table 4) fall within the threatened categories (Critically Endangered, Endangered and Vulnerable). Emicocarpus fissifolius has been listed under the Extinct (EX) category as this species was not found within its known range of 200 km^2 despite considerable effort spent searching for it. Two species (Dicerocaryum forbesii and Vangueria monteiroi) were assessed as Least Concern (LC). Dicerocaryum forbesii is only known from disturbed areas and is locally abundant where it occurs while V. monteiroi is found in both pristine and disturbed habitats in relatively large populations.

Table 4: Species assessed against IUCN 3.1 RDL with their IUCN Categories and the Criteria that they qualified under.

Family	Species	Growth form	Assessed IUCN status
Acanthaceae	*Sclerochiton apiculatus*	Shrub or climber	VU B1ab(ii,iii, v)+ 2ab(ii,iii,v)
Apocynaceae	*Emicocarpus fissifolius*	Prostrate herb	EX
Arecaceae	*Raphia australis*	Palm tree	VU A3c; B1ab(iii)+2ab(iii)
Asteraceae	*Distephanus inhacensis*	Liana	EN A4c; B2ab(i, ii, iii, v)
Malpighiaceae	*Acridocarpus natalitius* var. *linearifolius*	Scrambling shrub	VU A4c;C1
Melastomataceae	*Memecylon* sp nov	Medium tree	CR A3cd; B1ab(I, ii, iii, v)+2b(iii); C2a(ii)
Melastomataceae	*Warneckea parvifolia*	Shrub	EN A3c+4c; B1ab(i,ii,iii,v)+2b(ii,iii,v)
Pedaliaceae	*Dicerocaryum forbesii*	Prostrate herb	LC
Rubiaceae	*Empogona maputensis*	Small shrub	EN A4d; B1ab(I, ii, iii, v) + 2ab(I, ii, iii, v)
Rubiaceae	*Pavetta vanwykiana*	Suffrutex	VU B1ab(ii,iii,iv,v)
Rubiaceae	*Psydrax fragrantissima*	Shrub	EN A3c+4c
Rubiaceae	*Vangueria monteiroi*	Scrambling shrub	LC
Rutaceae	*Zanthoxylum delagoense*	Tree	VU A4cd; B1ab(ii, iii, v)+2ab(ii, iii, v)

The summaries below (see Figures 7a to 7m) provide the rationale for the assessment of each of the species as well as the known distribution of each species in southern Mozambique and northern KwaZulu-Natal. A fuller description for each species is provided in Appendix B.

3.3.1 Acanthaceae: *Sclerochiton apiculatus*

***Sclerochiton apiculatus* (VU B1ab(ii,iii,v)+2ab(ii,iii,v))**

Sclerochiton apiculatus is endemic to the MCE. The species occupies a limited EOO of 3626 km^2 and it is known from eight locations. The ongoing development and habitat degradation in both Mozambique and South Africa, is increasingly reducing suitable habitat of this species. Development includes expansion of urban areas, increase in land allocation for food production, human settlement, and building of new infrastructures. Habitat degradation in the form of deforestation for fuel and charcoal production is causing rapid and ongoing loss of this species habitat particularly in Mozambique. *Sclerochiton apiculatus* qualifies as Vulnerable under criteria B1ab(ii,iii,v) + 2ab(ii,iii,v).

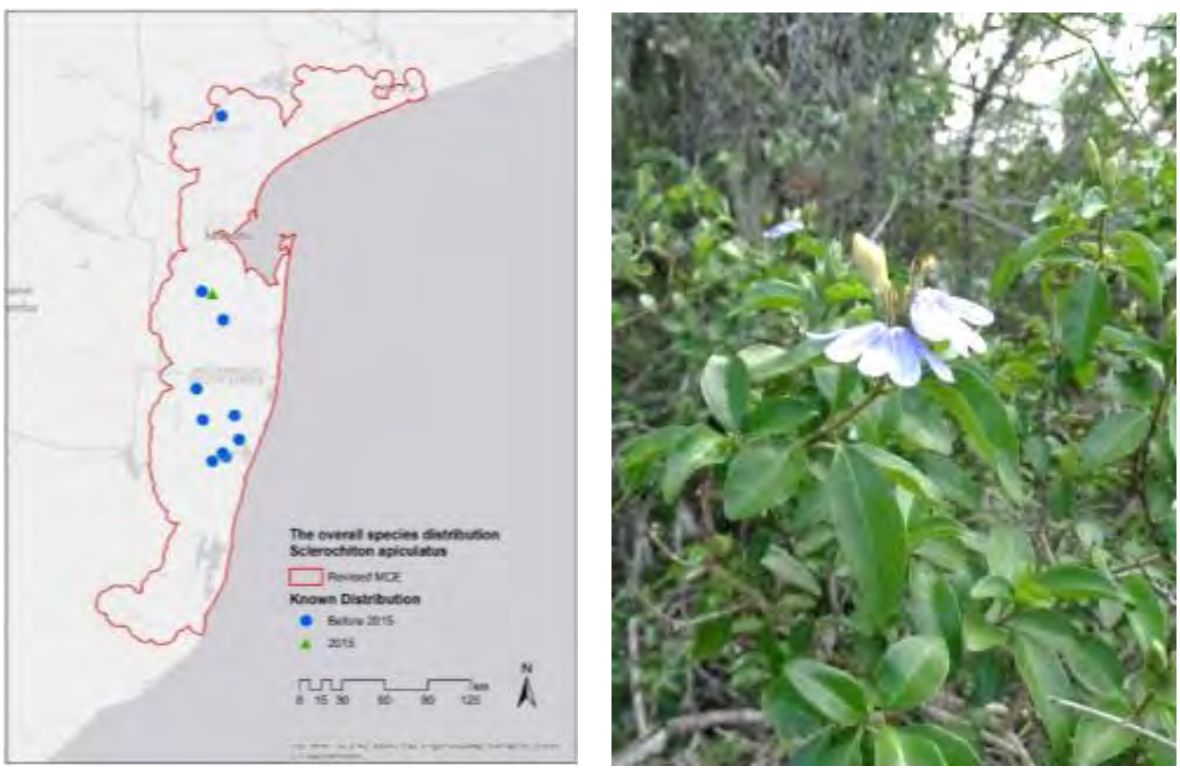


Figure 7a: *Sclerochiton apiculatus* is distributed within forest sand forest patches in the MCE. The image on the right shows the species in flowers.

3.3.2 Apocynaceae: *Emicocarpus fissifolius*

<u>Emicocarpus fissifolius</u> (EX)

Emicocarpus fissifolius was first collected in 1893 in what was known as Lourenço Marques, Delagoa Bay, present day Maputo city. In 1966, the last collection was made (Goydeder unpublished ms) in Maputo city. Since then, it has not been possible to find the species within its very small historical known range of five localities. All these localities where the species was collected have been transformed by urban development. Searches in similar suitable remaining habitat within its known range took place twice during the growing season (January and October) in 2015. This taxon was not found and the habitat, which was checked during this study, was found to be highly degraded. It is suspected that no more suitable habitat remains for this species, and it is therefore considered appropriate to list the species as Extinct (EX).

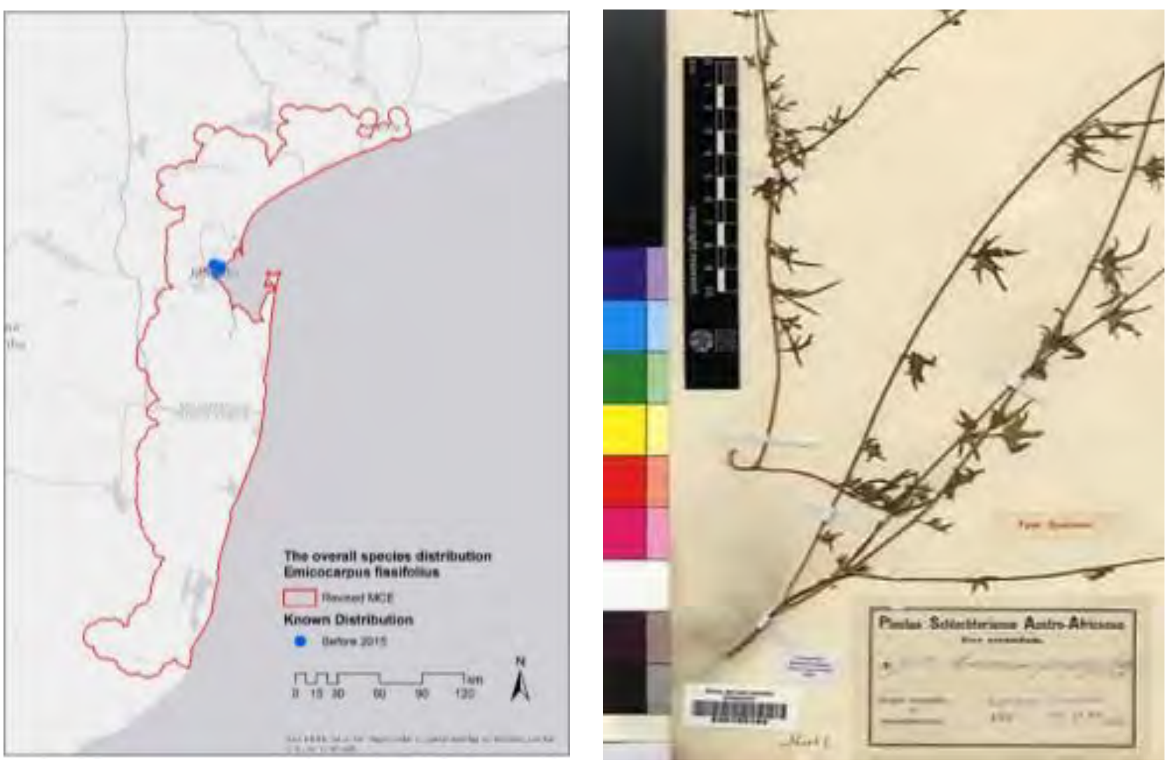


Figure 7b: *Emicocarpus fissifolius* was only known from the current Maputo city with no record from anywhere else. The image on the right shows the specimen of the *Emicocarpus fissifolius* taken at the Royal Botanic Gardens, Kew.

3.3.3 Arecaceae: *Raphia australis.*

Raphia australis (VU A3c; B1ab(iii)+2ab(iii))

R. australis is an endemic to the MCE, occupying 6762.75 km^2 of EOO, known from a total of three subpopulations. There are two subpopulations in Mozambique, and one in South Africa. This species is restricted to swamps and seasonally inundated dunes with an AOO of 56 km^2. There are seven locations, three of which are experiencing ongoing decline in habitat quality due to subsistence farming and urban housing development. A further 30 - 40% of the population is predicted to be lost due to expected expansion of large-scale rice cultivation in concessions provided to the Chinese government by the Mozambican authorities. This species with generation length of 30 years it flowers once at the age between 20 to 40 years then it dies two to three years after fruiting. Taking into consideration the increasing threat, *R. australis* has been upgraded from Data Deficient (DD) to Vulnerable A3c; B1ab(iii)+2ab(iii).

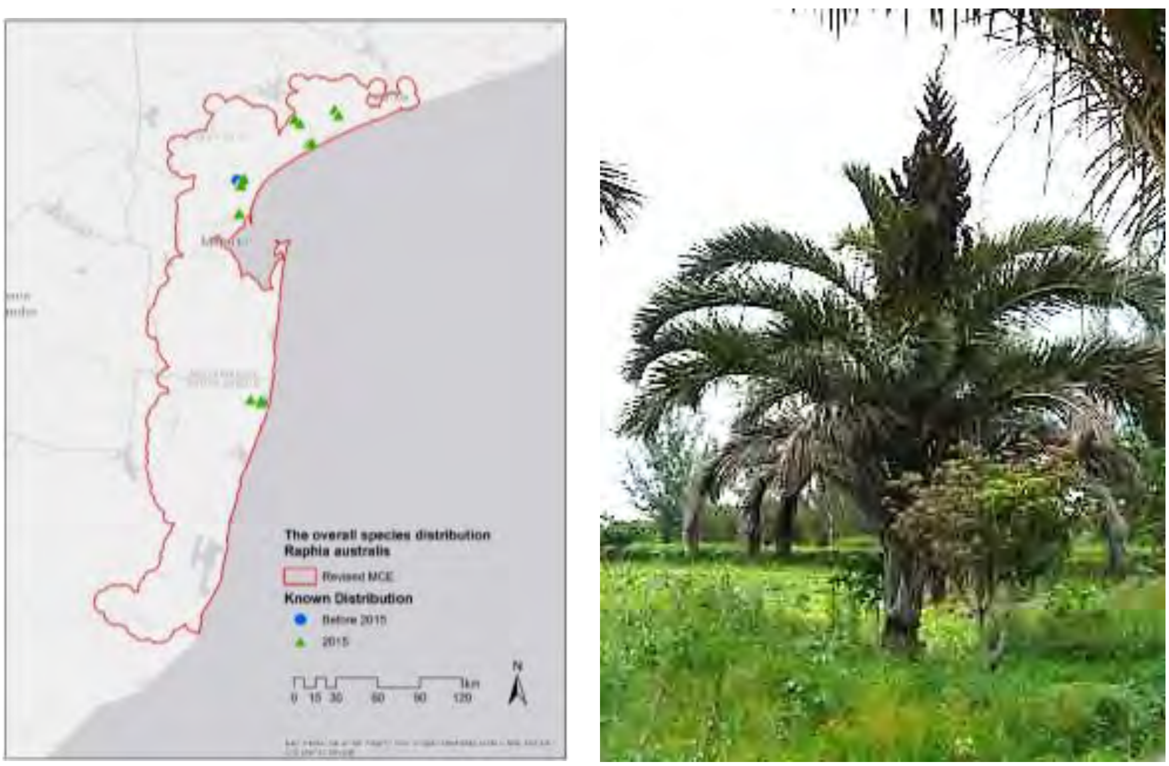


Figure 7c: Herbarium and field distribution records are shown in blue and green respectively. The image on the right is the *Raphia australis* flowering (terminal inflorescence).

3.3.4 Asteraceae: *Distephanus inhacensis*

<u>Distephanus inhacensis</u> (EN A4c; B2ab(i, ii, iii, v))

This species is an endemic to the MCE, and it has an EOO of 9789 km^2 with 56 km^2 AOO. There may still be other suitable habitat that has not yet been surveyed. However, the coastal and dry forest habitat of this species within the Maputaland plain is limited and the maximum AOO is not likely to be more than 300 km^2. The species is known from 10 locations throughout its range in South Africa, KwaZulu-Natal, and in southern Mozambique up to Gaza province. Although the species occurs in some well-protected areas such as Sodwana Bay National Park and Tembe Elephant Park, more than half of the population occurs within areas susceptible to transformation. There is ongoing pressure for timber, and charcoal extraction within the LFR including the dry forest around as far south as Ponta do Ouro. In addition, tourism expansion around Ponta do Ouro is removing the dunes where the species is found. This is a long lived species with a generation time of at least 40 years. Past deforestation has led to 10% loss of the population over the last 80 years. A further 50% of the population is predicted to be lost due to deforestation in southern Mozambique over the next 100 years. Taking this into consideration, the species has been assessed as Endangered A4c; B2ab(i, ii, iii, v).

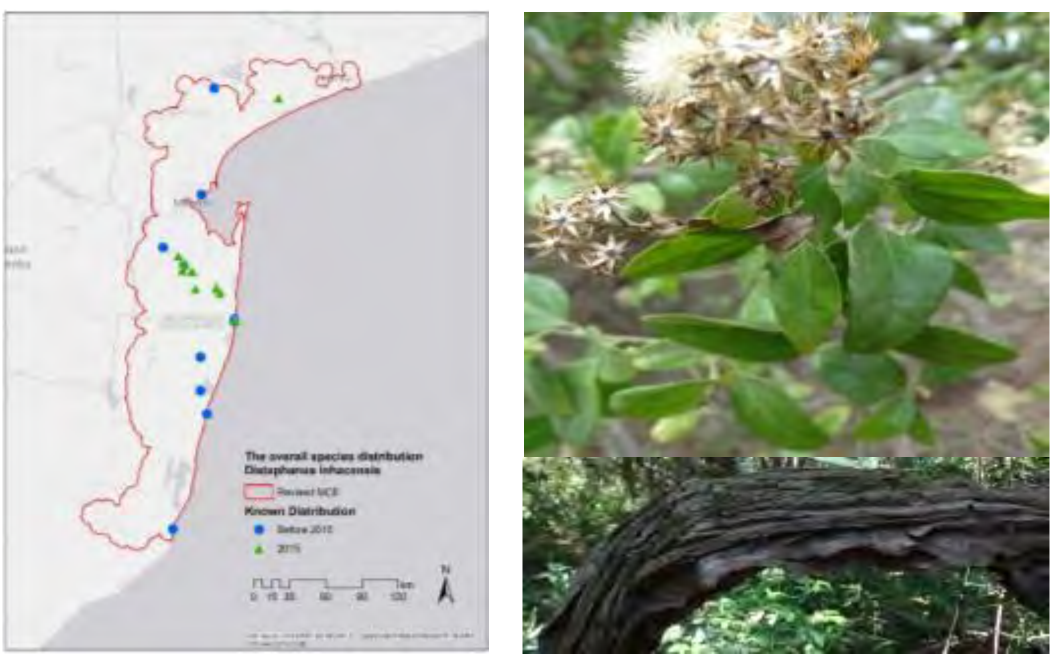


Figure 7d: *Distephanus inhacensis* is distributed evenly throughout the MCE within sand forests. Its deeply fissured bark, as shown on the image on the right, makes it easy to identify in the field.

3.3.5 Malpighiaceae: *Acridocarpus natalitius* var. *linearifolius*

Acridocarpus natalitius* var. *linearifolius (VU A4c;C1)

Acridocarpus natalitius var. *linearifolius* is endemic to the MCE and occupies an EOO of 23,234 km^2. This taxon occurs as sparsely scattered individuals throughout the Maputaland coastal plain and also a few sporadic occurrences have been recorded further inland on sandy soils at higher altitude. Surveys within southern Mozambique have confirmed the sparse distribution of this taxon and allow an extrapolation of the population to fewer than 10 000 individuals. The roots of *Acridocarpus natalitius* var. *linearifolius* have been documented as being used for medicine (Williams et al. 2001). Medicinal use combined with past habitat transformation has led to a 10% decline in the population over the past 45 years with future loss to urban and agricultural development suspected to cause a further 20% of the population to be lost by 2040 (generation time 30 years). Therefore, the species has been assessed as Vulnerable under criterion A4c; C1.

Figure 7e: Although concentrated in the low lying coastal plain, *Acridocarpus natalitius var.* linearifolius (right) is widespread within the MCE including some records from high altitude sites in areas such as Jozini in KwaZulu-Natal, South Africa.

3.3.6 Melastomataceae: *Memecylon* sp. nov.

***Memecylon* sp nov.** (CR A3cd; B1ab(i, ii, iii, v)+2b(iii); C2a(ii))

A review of African members of the genera *Memecylon* and *Warneckea* by R.D.Stone, using DNA information, has shown that this taxon is undescribed and now awaits full description (Burrows, pers. comm). Flowering material collected during this study has provided the essential first flowering material that will enable it to now receive a name.

Memecylon sp. nov. is known from a single forest patch (EOO and AOO ≤ 0.005 km^2) with about 21 counted individuals. Although previously protected as a sacred forest by surrounding communities, the increasing demand for wood to turn into charcoal and land for agriculture has resulted in sections of the forest being burnt. The increasing human population in the surrounding areas and ongoing escalation in demand for agricultural land and wood for charcoal production is highly likely to deplete the single known location of the species in a short time (± 20 years). As a result, *Memecylon* sp. nov. which has a suspected generation time of 40 years, has been listed as Critically Endangered A3cd; B1ab(i,ii,iii,v)+2b(iii); C2a(ii).

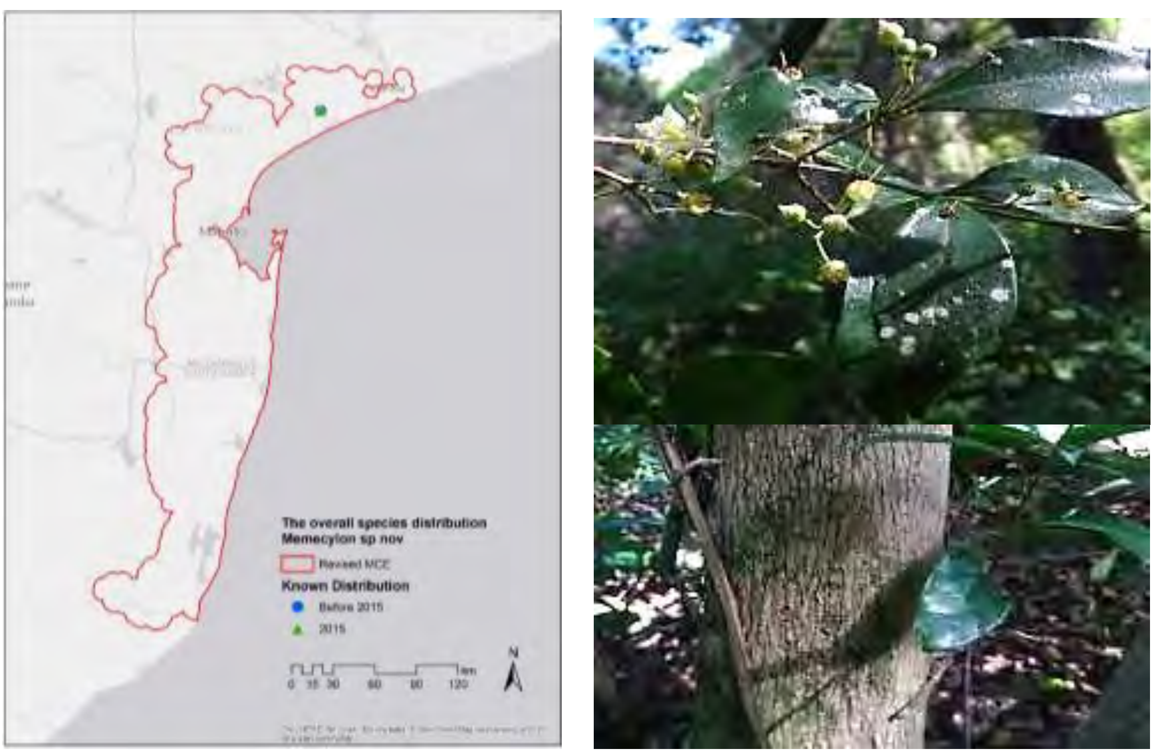


Figure 7f: *Memecylon* sp. nov. (right) is a species with very restricted range of occurrence and is known from an area less than 1 km^2 in Macia towards the northern end of the MCE.

3.3.7 Melastomataceae: *Warneckea parvifolia*

<u>Warneckea parvifolia</u> (EN A3c+4c; B1ab(i,ii,iii,v)+2b(ii,iii,v))

Warneckea parvifolia is an endemic to the MCE (EOO 400 km^2), and is known from two locations, one in Tembe Elephant Park, KwaZulu-Natal South Africa and the other at the LFR in Maputo province, southern Mozambique. Despite being a reserve, the LFR is under severe ongoing degradation which may have resulted in 20% loss of the species. If the degradation continues at the current observed rate, it is suspected that about 80% of the species in this area will be lost by 2040. The 80% loss of the LFR's subpopulation, relates to an overall loss of 50% to the entire known population. Given that *Warneckea parvifolia* is a long-lived slow growing resprouting species with a minimum generation length of 100 years, it has been listed under Endangered A3c+4c; B1ab(i,ii,iii,v)+2b(ii,iii,v).

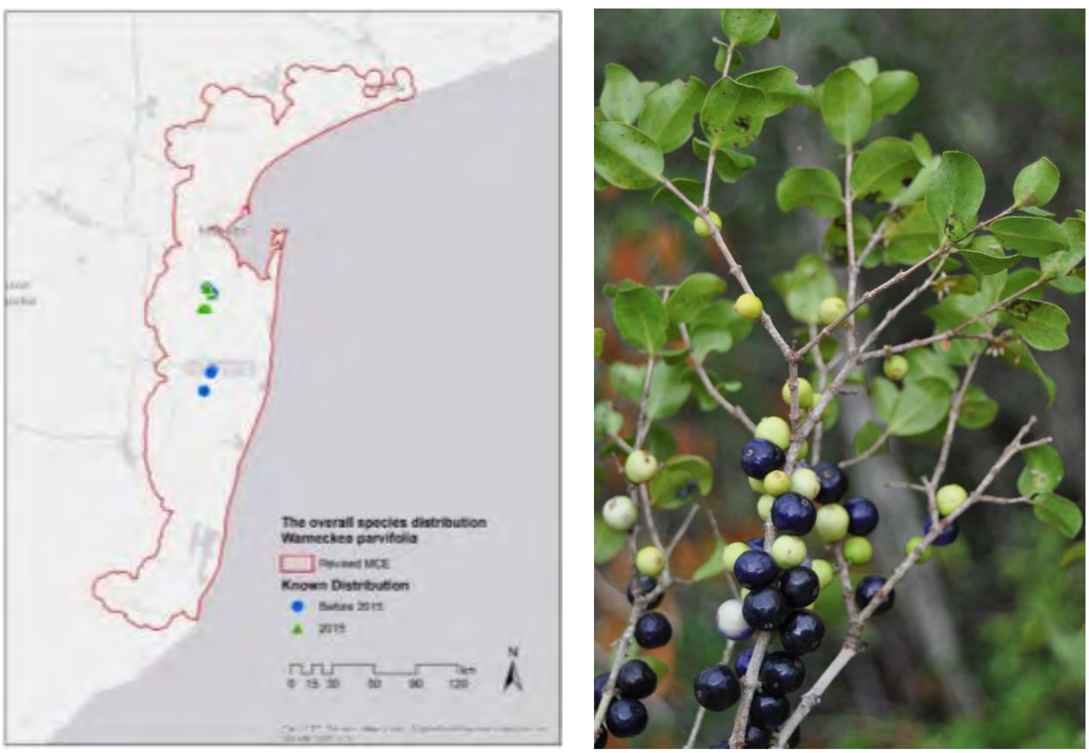


Figure 7g: The distribution of *Warneckea parvifolia*. The species is one of the characteristic species of the thicket vegetation of the LFR.

3.3.8 Pedaliaceae: *Dicerocaryum forbesii*

<u>Dicerocaryum forbesii</u> (LC)

Dicerocaryum forbesii is an endemic to the Maputaland Centre of Endemism (EOO 182.9 km^2). The species is known from Mkhuze in Northern KwaZulu-Natal to the LFR in Southern Mozambique. Despite being a restricted endemic this taxon favors disturbance and occurs where forest areas have been opened up. Under the dominant land uses of shifting agriculture and cutting of forest for charcoal and wood, available habitat is increasing for this species. It is therefore listed as Least Concern.

Figure 7h: *Dicerocaryum forbesii* is found within disturbed areas such as grazed sites, and abandoned cultivated fields as shown on the image on the right.

3.3.9 Rubiaceae: *Empogana maputensis*

<u>Empogona maputensis</u> (EN A4d; B1ab (i, ii, iii, v) + 2ab (i, ii, iii, v))

Empogona maputensis is an endemic to the MCE (EOO 151 km^2, AOO 138 km^2) and is known from only two locations at the LFR in Maputo province southern Mozambique where it occurs in the understory of the Licuati thicket vegetation. There is severe ongoing habitat degradation due to charcoal production (Izidine et al. 2008). As one of the closest sources of charcoal for Maputo, Licuati Thicket is expected to be placed under severe pressure for wood and charcoal in the future. Past loss and degradation of habitat at Licuati due to timber and agriculture concessions (Gomes e Sousa, 1968), as well as harvesting is suspected to have resulted in 20% loss to the population. Between 1973 and 2033 a decline of 60% of the population is expected. Therefore, *Empogona maputensis* (with generation length of 20 years) has been assessed as Endangered A4d; B1ab (i, ii, iii, v) + 2ab (i, ii, iii, v).

Figure 7i: Very restricted distribution of the *Empogona maputensis* (known only from the LFR in southern Maputo) as shown on the map. The image on the right shows *Empogona maputensis* with fruits.

3.3.10 Rubiaceae: *Pavetta vanwykiana*

Pavetta vanwykiana (VU B1b (i, ii, iii,iv,v))

Pavetta vanwykiana is an endemic to the MCE. The species occupies an EOO of 4450 km^2 and it is known from four subpopulations and eight locations. Throughout the species range (northern KwaZulu-Natal and southern Mozambique) there is ongoing conversion of this taxon's habitat for charcoal production, shifting agriculture, human settlement, as well as building of infrastructure for new industry. This species thus qualifies for listing as Vulnerable B1b (ii, iii,iv,v).

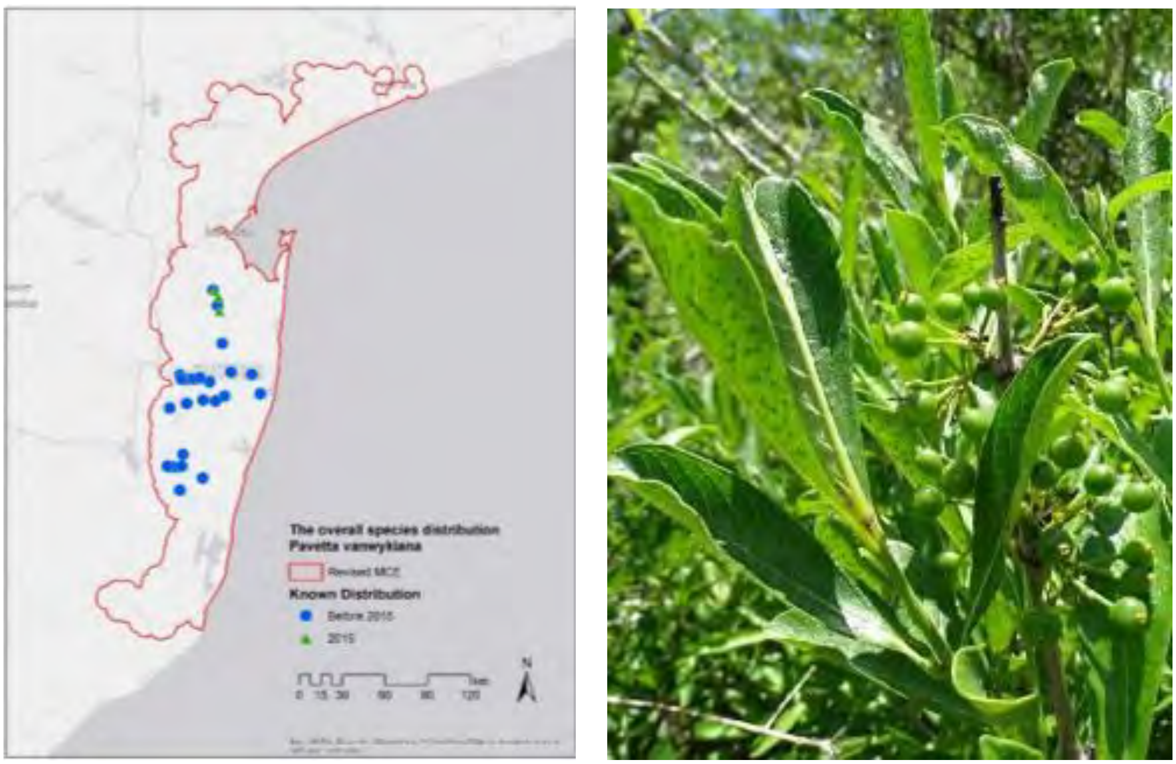


Figure 7j: Distribution of the *Pavetta vanwykiana*. This species has very distinctive dots on the leaves visible on the photograph on the right. The fruits are axillary clustered.

3.3.11 Rubiaceae: *Psydrax fragrantissima*

Psydrax fragrantissima (EN A3c+4c)

Psydrax fragrantissima is endemic to the MCE. This species, with an EOO 6501 km^2, is known from 10 locations. Although well-conserved in South Africa the main part of the population occurs in the LFR. Since 1943, the LFR has been under habitat loss due to timber and agriculture concessions which is suspected to have resulted in 20% loss to the overall population. As the LFR is one of the closest sources of charcoal for Maputo, it is under severe ongoing pressure (Sitoe et al. 2013). Therefore, it is inferred that about 70% of the overall population may be lost by 2040. This is a slow growing resprouting species with a minimum generation time of 50 years. Therefore, the species is assessed as Endangered A3c+4c.

Figure 7k: *Psydrax fragrantissima* is one of the characteristic species of the thicket vegetation. It has a fragrant sense to which it has been named after.

3.3.12 Rubiaceae: *Vangueria monteiroi*

<u>Vangueria monteiroi</u> (LC)

Vangueria monteiroi is endemic to the MCE and it has an EOO of 10033 km^2. The species occurs as sparsely scattered individuals in bushveld, coastal and sand dune forest habitat throughout its known range and appears to be able to survive well in areas that have previously been disturbed. The majority of this species' habitat occurs outside of protected areas. The predominant land use in these areas is subsistence agriculture and a high dependence on fuel (wood and charcoal) from forests. Extensive degradation has therefore taken place. Field surveys conducted as part of this study indicate that this species is able to survive moderate disturbance and with ongoing woodland and forest degradation its habitat is likely to be increasing. Therefore, it was found appropriate to list the species as Least Concern (LC).

Figure 7l: The distribution of *Vangueria monteiroi* shows that the species occurs in areas where disturbance from human activities has occurred. The image on the right shows the species in flowers and fruits.

3.3.13 Rutaceae: *Zanthoxylum delagoense*

Zanthoxylum delagoense (VU A4cd; B1ab(ii,iii,v)+2ab(ii,iii,v))

Zanthoxylum delagoense is a near endemic to the MCE, and is an endemic to Mozambique. It is found along the coastline from Maputo to Inhambane Provinces in southern Mozambique. This range overlaps with high human concentration. Therefore, large portions of the species habitat have experienced past disturbance and continue to experience ongoing degradation due to forestry resources exploitation, subsistence farming, and urbanization. With a generation time of 60 years, this species is thought to have declined by 15% since 1943 and is expected to experience a further 20% decline by 2080. It therefore qualifies for the IUCN status of Vulnerable under criterion A4cd; B1ab(ii, ii, v)+2ab(ii, iii, v).

Figure 7m: *Zanthoxylum delagoense* is currently known from southern Mozambique. The species bark, as on the image on the right, helps to recognize it in the field.

3.4 Number of records, EOO and AOO for the 13 assessed species

More than 50% of species are highly restricted with EOO's less than 5000 km^2 or just above this figure. In addition, the results (Table 5) shows that more than 50% have a very restricted AOO. This is due to many of the species (at least eight) being limited to forest patches which are continuously reducing their size resulting from degradation. *Memecylon* sp. nov. is the most restricted species with an EOO less than 1 km^2.

Table 5: EOO and AOO of the 13 study species under the IUCN Red Listing criteria.

Family	Species	Nº records	EOO (km^2)	AOO (km^2)	IUCN Status
Acanthaceae	*Sclerochiton apiculatus*	13	3 626	48	VU
Apocynaceae	*Emicocarpus fissifolius*	-	-	-	EX
Arecaceae	*Raphia australis*	34	6 763	56	VU
Asteraceae	*Distephanus inhacensis*	24	9 790	56	EN
Malpighiaceae	*Acridocarpus natalitius* var. *linearifolius*	50	23 234	124	VU
Melastomataceae	*Memecylon* sp nov	9	0.005	0.005	CR
Melastomataceae	*Warneckea parvifolia*	25	401	40	EN
Pedaliaceae	*Dicerocaryum forbesii*	29	2 336	60	LC
Rubiaceae	*Empogona maputensis*	14	13	16	EN
Rubiaceae	*Pavetta vanwykiana*	39	4 451	112	VU
Rubiaceae	*Psydrax fragrantissima*	33	6 502	76	EN
Rubiaceae	*Vangueria monteiroi*	29	10 034	64	LC
Rutaceae	*Zanthoxylum delagoense*	38	28 895	80	VU

3.5 Species distribution modeling using MaxEnt

Figure 8 (a, b and c) displays the results of the potential distribution of the 12 modelled species. The models set for the 12 species showed high average values of Area Under the Curve (AUC) for the replicate runs ranging from 0.95 to 0.99. The models shows a wide range of potential habitat for the majority (eight) of the study species. Some species show a narrow potential suitable habitat. For example *Memecylon* sp. nov. is restricted to the northern MCE (Macia district), *Empogona maputensis* is restricted to the Licuati thicket while *Warneckea parvifolia* is restricted to the Licuati thicket and Tembe Elephant Park. The model for *Raphia australis* shows a high potential suitable habitat to the north of the MCE (i.e. Macia district).

The variables differed in the level of their importance in explaining the distribution patterns of each species, although soil was the most important variable for the majority (seven) of the study species. Soil was the most important variable in explaining 77.5% of the modeled distribution for *Dicerocaryum forbesii*, 68.4% for *Warneckea parvifolia*, 67% for *Sclerochiton apiculatus*, 54% for *Psydrax fragrantissima*, 45.5% for *Empogona maputensis*, 32% for *Pavetta vanwykiana*, and 26.4% for *Memecylon* sp. nov. Precipitation was found to be the most important predictor variable for the remaining five species with 44.7% for *Raphia australis*, 41.9% for *Zanthoxylum delagoense*, 36.4% for *Vangueria monteiroi*, 24.4% for *Acridocarpus natalitius var. linearifolius*, and 23.8% for *Distephanus inhacensis*. The distribution of species that are not restricted to small habitat patches, for example *Acridocarpus natalitius var. linearifolius* and *Vangueria monteiroi*, are explained by more than two variables in the following descending order: precipitation, soil, and temperature.

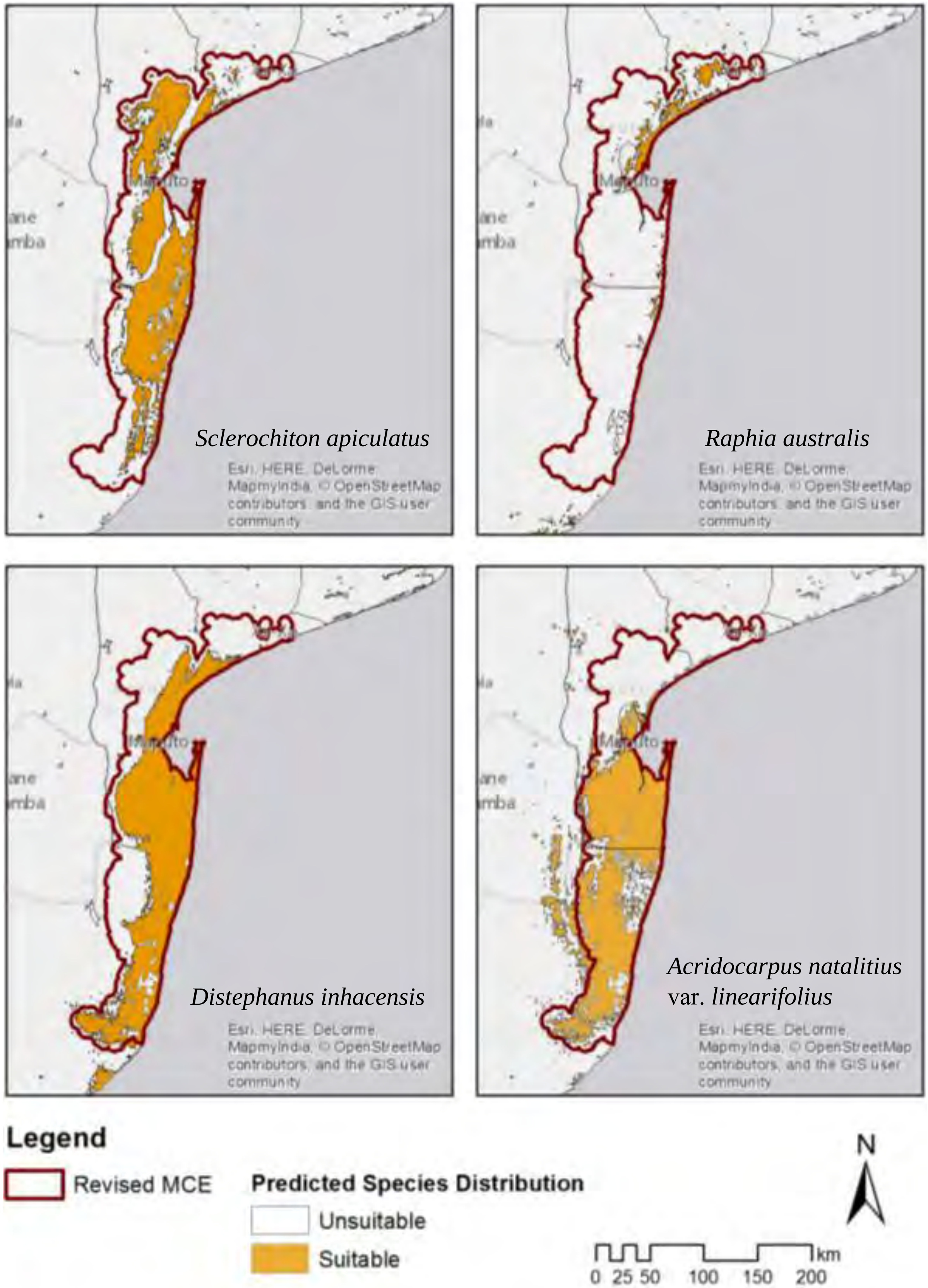


Figure 8a: MaxEnt models for the selected MCE endemic and near endemic plant species.

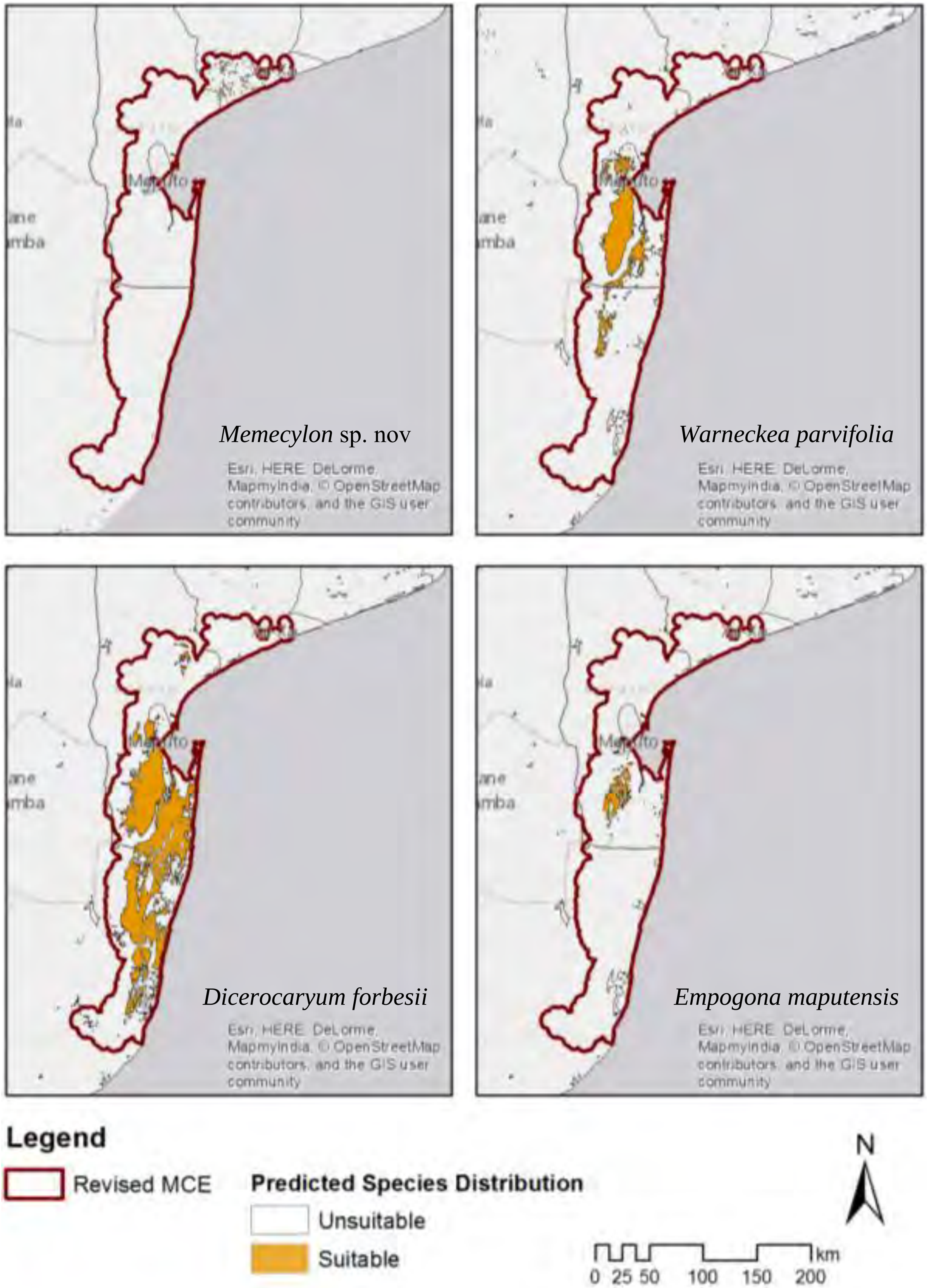


Figure 8b: MaxEnt models for the selected MCE endemic and near endemic plant species.

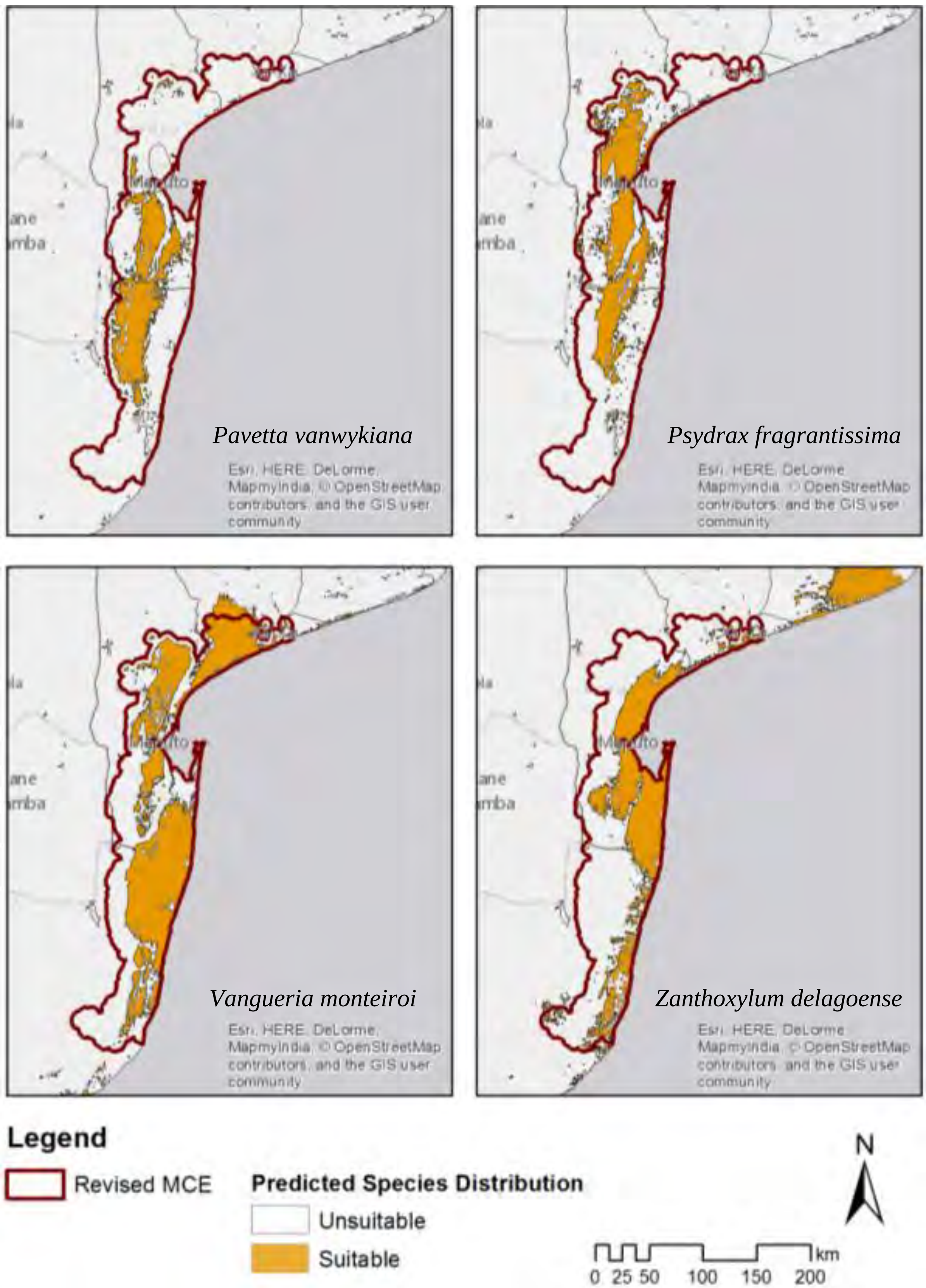


Figure 8c: MaxEnt models for the selected MCE endemic and near endemic plant species.

3.6 Hotspots analysis and identified core priority areas for conservation

The combined area which is occupied by 12 of the MCE endemic and near endemic plant species is 2 565 385 ha (Figure 9A). However, the core priority area, which is defined as the area where 50% of the MCE endemic and near endemic plant species overlap in their distribution and which could be used for conservation planning or protected area expansion, is 277 526 ha (Figure 9B). In southern Mozambique, the core priority area identified occurs predominantly in the Matutuine district in southern Maputo although it also includes portions of three other southern districts, namely Boane, Matola, and Marracuene. However, the biggest portion is within Matutuine district which includes the Licuati Forest Reserve (LFR) and the south-west area of the Maputo Special Elephant Reserve south to the border with South Africa. In South Africa, the areas that were identified as priority areas stretch from Ezineshe and UMkhuze, northwards through Mozi, Shemula, Mbodla including part of the Tembe Elephant Park.

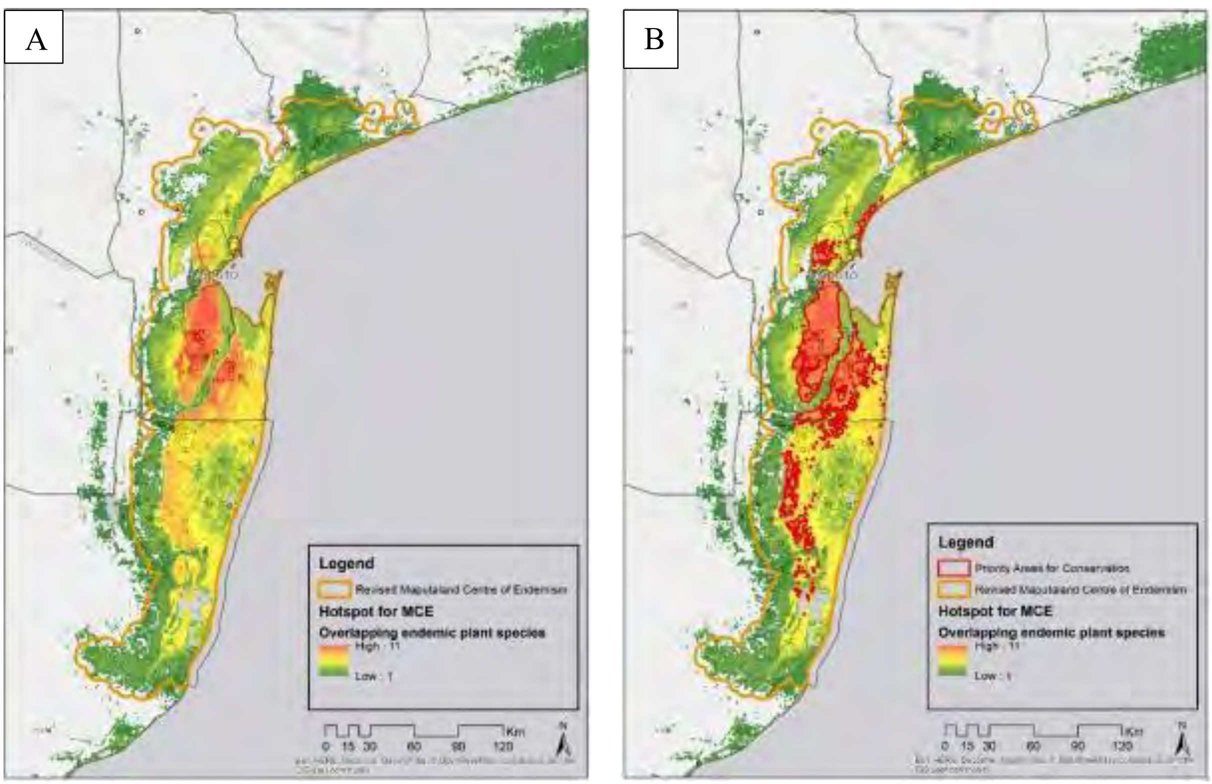


Figure 9: Hotspot analysis of the Maputaland Centre of Endemism. The map A, on the left, shows the full extent of the MCE (2 565 385 ha) as determined in this study. The legend shows the value for 11 overlapping species as two species did not overlap in their modelled distributions. The map B, on the right, represents the priority or core area for conservation (277 526 ha).

The use of overlapping species distribution models to identify priority areas provides a relatively objective approach to conservation planning. However, species such as *Raphia australis,* which occur in a different habitat type, such as swamp vegetation and inundated valleys from other species which are distributed in sandy forest or thicket, do not contribute to the delineation of potential priority conservation areas. *Raphia australis* is concentrated at the northern end of the MCE at Bilene in Macia district and Calanga in Manhica district and special conservation measures are needed in order to ensure the future survival of this species.

3.7 Extent of protected areas in the MCE as defined for this survey

Within the MCE there are protected areas (Figure 10a) which comprise 22.9% (Figure 10c) of the total area. Of this area 14.9% is in South Africa and 8.0% is in Mozambique (Figure 10b). Further analysis shows that only 28.4% (Figure 10c) of the core priority areas identified in this study are already protected with 2.5% in South Africa and 25.9% in Mozambique. The majority of the core priority area identified as protected in Mozambique is the Licuati Forest Reserve (Figure 10b). Despite many more protected areas existing within the South African portion of the MCE, with the exception of a small portion of Tembe Elephant Park, the majority of these protected areas are not affording protection to the habitat of these selected endemic plants.

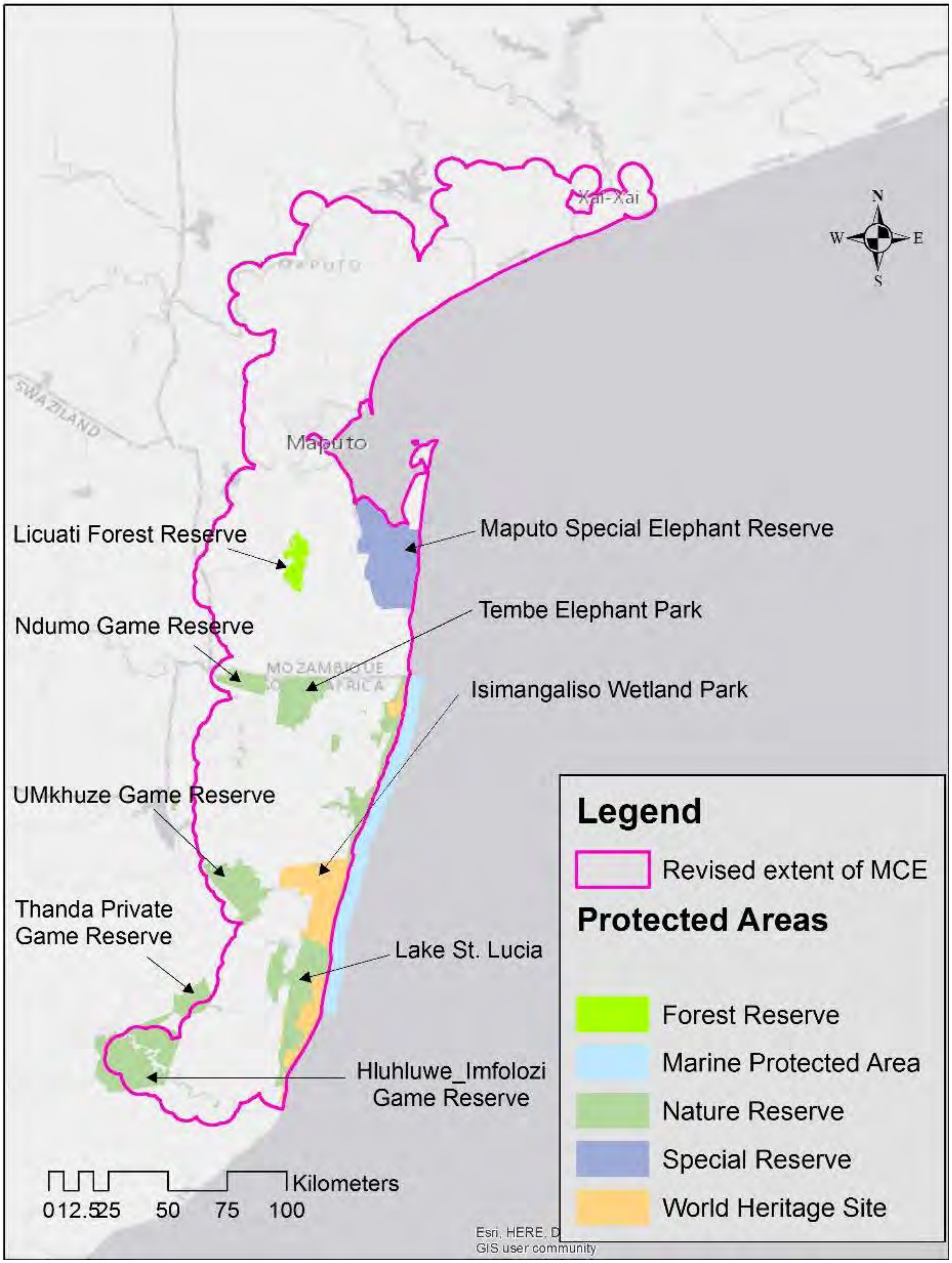


Figure 10a: Location of existing protected areas in the revised Maputaland Centre of Endemism.

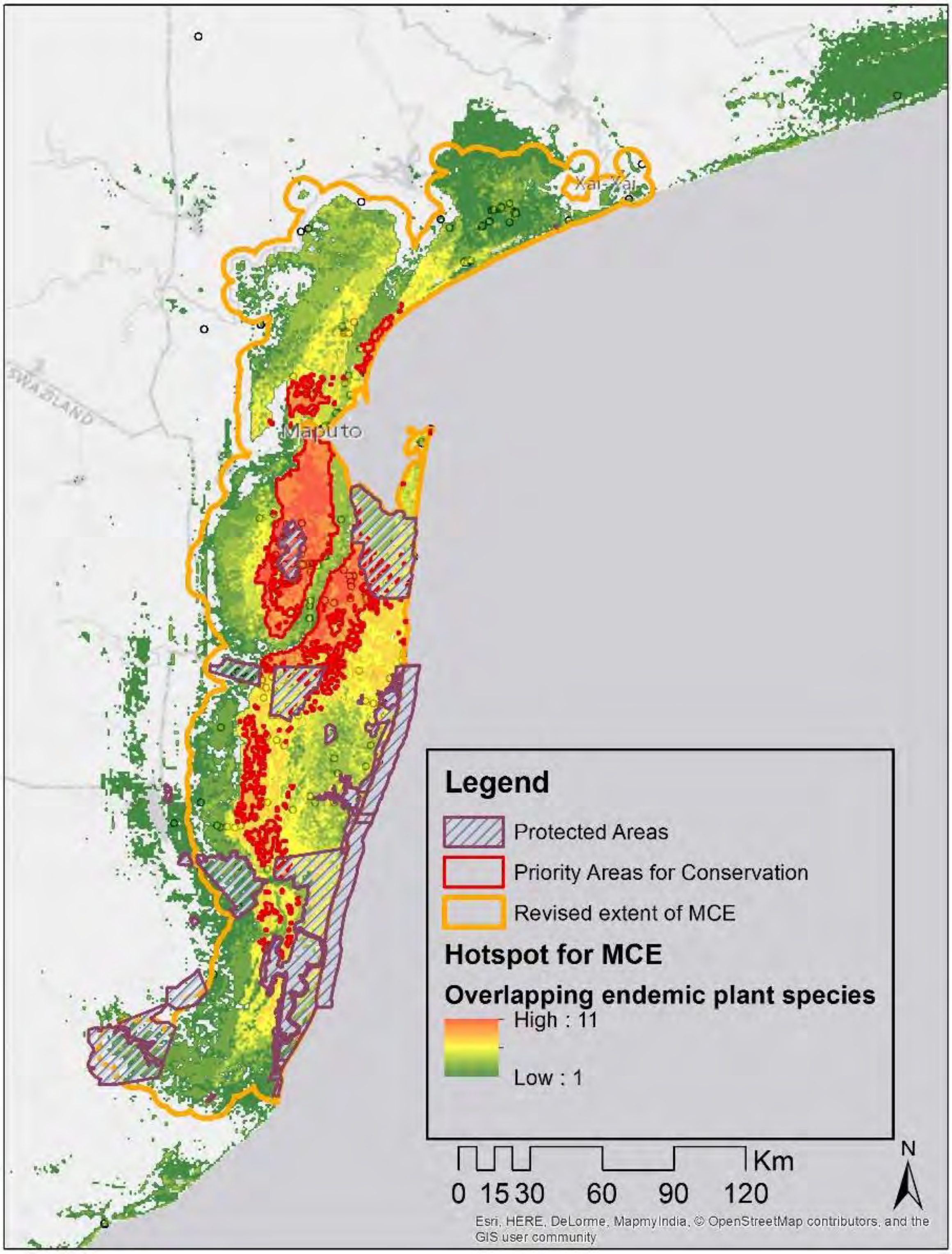


Figure 10b: Overlapping the identified core priority areas (red) with existing protected areas.

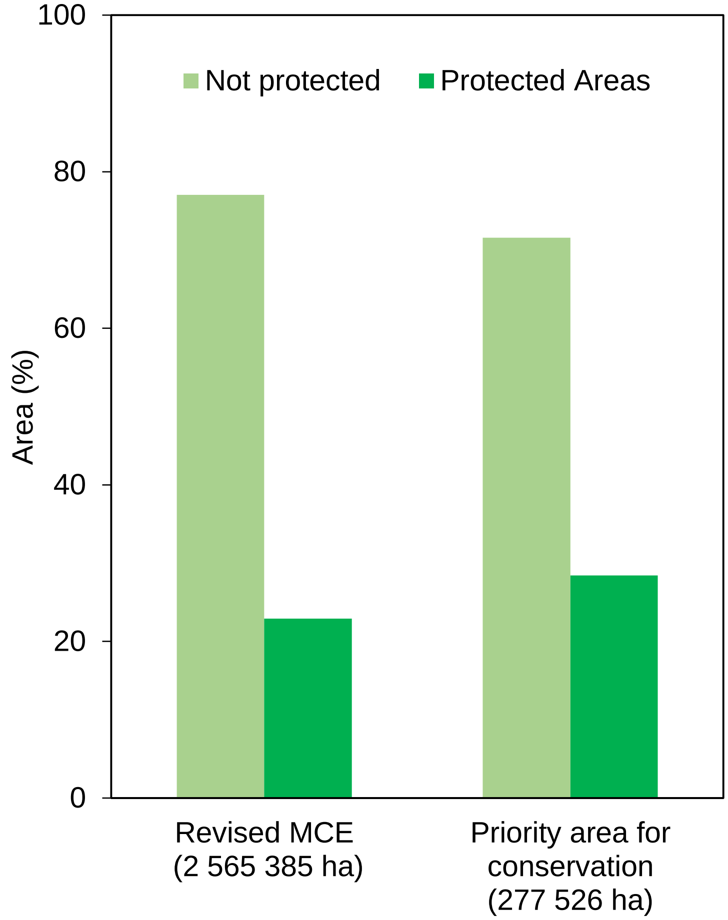


Figure 10c: Size of existing protected areas within the revised MCE as well as within the core priority area for conservation as determined from the overlapping distribution of the MCE endemic and near endemic species investigated in this study.

4. DISCUSSION

4.1 Spatial distribution of the MCE endemic and near endemic plants

Nearly two-thirds of the area of the Maputaland Centre of Endemism (MCE) sensu van Wyk (1996) lies within Mozambique. However, at the start of this study there were three times as many occurrence records of the 13 targeted species from the KwaZulu-Natal area of the MCE compared with southern Mozambique. This shows that there is a collecting bias towards South Africa and highlights how poorly-collected Mozambique is as a country. Mozambique has remained poorly sampled due to a number of factors, including the lack of taxonomists after independence in 1975, and the civil war from 1976 to 1992 that resulted in planting of land mines across large areas in the country as well as limited financial aid to carry out botanical surveys (da Silva et al. 2004). Poor knowledge of species occurrences and distributions due to a lack of field survey work is a major challenge for many poor developing countries (Callmander et al. 2005; Rodrigues et al. 2006; Wulff et al. 2013). This study has resulted in a doubling of the number of occurrence records for the target species (424 previously available versus 889 post-field surveys), which has allowed for accurate Red List assessments to be conducted and also provided sufficient data to model species distributions using MaxEnt. To run MaxEnt, a minimum of 10 to 30 occurrence points are required. However, the model's performance increases with the number of records (Pearson et al. 2007; Costa et al. 2010; Feeley & Silman 2011).

The new distribution records combined with the modeled distributions showed that the species being studied are not equally distributed across the MCE. Areas of high concentration of endemics include the Licuati thicket south of Maputo, Tembe Elephant Park, and UMkhuze in KwaZulu-Natal. These three areas share a common vegetation type called short sand forest in KwaZulu-Natal (Gaugris & Rooyen 2007) and Licuati thicket in southern Mozambique (Izidine et al. 2003). The concentration of endemics can be attributed mainly to the unique edaphic environment of poor nutrient sandy soils of ancient dunes (van Wyk 1996, van Wyk & Smith 2001; Izidine et al. 2003) located within 50 to 80 km from the coast, with low rainfall averaging 35.3 mm per month (a total of about 400 mm per annum) (INE 2012). These conditions have led to the evolution of a unique flora with the majority of species being shallow rooted and coppicing from an extensive root mass. Species are long-lived and there is little regeneration from seeds (Bridson 2001; Boon 2010).

The only species that does not overlap in its distribution with other endemics and represents an outlier in this analysis is *Raphia australis,* common towards the northern end of the MCE. The littoral zone of Bilene Macia where the species occurs has high rainfall, ranging from 800 to 1000 mm per annum, compared to the interior which varies from 500 to 800 mm (MAE 2005). In addition, the north east littoral of Bilene Macia district is where the flooed valleys and swamps are extensive as they occur relatively close to the mouth of the Limpopo River. Given the extensive flooded areas along the Limpopo River, the area is suitable for large scale production of crops such as wheat, rice, and maize (CGIAR 2014), which may become a major threat to *R. australis*.

4.2 Major threats to the MCE endemic and near endemic plants

The predominant threat to the MCE endemic and near endemic plants is the loss of suitable habitat (Gaugris & van Rooyen 2007; Graham et al. 2012). Graham et al. (2012) noted that some areas of sand forests that are found between Mbazwana and Gezisa in KwaZulu-Natal South Africa, are experiencing ongoing degradation due to human settlement. Several studies (Drigo et al. 2008; Sitoe et al. 2012; Sitoe et al. 2013) found that commercial farming, shifting land for subsistence farming, charcoal production, development of new infrastructure, and expansion of urban areas are the direct causes of deforestation in Mozambique. For example, a study by Sitoe et al. (2013) noted that the average land size used for subsistence agriculture per household in Maputo Province has increased from 60.2 ha in 2001 to 147.8 ha in 2010 which represents an increase of 145.7%. This contradicts results of the land cover analysis, which shows that a very small portion (less than 2%) of the land has been transformed (cultivated). The land cover data suggests that a significant (94.3%) portion of the area has not been transformed and instead is dominated by trees, bush, and grassland. However, by comparing these results with the satellite imagery from Google Earth (Figure 5), it is clear that the land cover data does not fully reflect the extent of transformation that has occurred in the region. The detailed information on the land cover data (see the table in Appendix C) illustrate that the transformed areas (non-natural areas) are impossible to distinguish, as some of the categories, such as “bare”, can include both natural (beaches) and unnatural areas (houses). Similarly, tree-dominated vegetation can occur in urban areas. The available land cover data also do not consider the condition of vegetation and, as a result, users cannot determine whether an area is degraded or not. For example, a heavily logged area may be mapped as “Low Vegetation and Grassland”. Charcoal harvesting and a change in ecological processes such as those that result from fire can also not be determined from a single analysis of imagery. A series of land cover images spanning several years would be required to accurately detect the changes. Direct observations of degradation at the Licuati Forest Reserve (LFR) over 20 years by botanists (John Burrows pers. comm.) and changes seen from Google Earth (Figure 5) indicate that forest degradation is taking place at a rapid rate. However, the land cover maps currently available provide very limited insights into the real extent of habitat transformation and degradation in the study area.

In order to improve our understanding of habitat transformation, deforestation and forest degradation, an additional analysis was undertaken using satellite images of forest cover change over the last 15 years. This analysis provides a far more sobering view of the extent to which forest habitats are being transformed in southern Mozambique and northern KwaZulu-Natal, where 8.3% and 14.4% respectively have been transformed since 2000. Even these values require verification, however, since the data includes plantations in KwaZulu-Natal in which areas cleared for extraction of planted timber were detected as forest loss and vice versa. Although the forest cover change data is more informative, both GEOTERRA IMAGE land cover data and Forest Coverage 2000 do not accurately convey the full extent of vegetation change and deforestation that is taking place in the region.

Given that nearly two-thirds of the area of the MCE lies within Mozambique, a closer understanding of the drivers of habitat change in this country is needed. In forest areas of Mozambique habitat degradation is mainly due to uncontrolled exploitation for charcoal production. This study identified three major locations where charcoal is being produced: the Bilene Macia district at the northern end of the MCE, the Licuati Forest Reserve (LFR) and Zitundo in the region south of Maputo. Charcoal production and collecting of firewood have a significantly higher impact in areas situated in close proximity to major cities or settlements such as Maputo, Matola, Beira and Nampula (Sitoe et al. 2013). This study found that within these three areas, the area of greatest concern is the LFR, which is situated about 50 km south of Maputo city.

The LFR was established in 1943 with the purpose of allowing a sustainable use of timber resources (Gomes e Sousa 1968). Since then, several institutional, governance and legislative weaknesses have exposed the reserve to intensive exploitation. Some issues of concern included unclear boundaries and a lack of enforcement. These weaknesses resulted in the LFR being reduced from 50,000 ha to 19,000 ha in the period up to 1963 (Gomes e Sousa 1968) due to the expansion of agricultural activity, timber exploitation and grazing during the colonial era. The rapid expansion of the Maputo city area, due to the high number of Mozambicans migrating from rural areas to the city because of job opportunities, has increased the pressure on the areas in the vicinity of Maputo and surrounding areas including the LFR. The reason for this is that people in areas surrounding the city have limited income to cover the expense of electricity and have a limited range of alternative sources of energy (Sitoe et al. 2013). The only affordable source of energy is charcoal and fire-wood, mainly for cooking and to heat water (Sitoe et al. 2013). Broto et al. (2014) noted that in *Bairro de* Chamanculo, an outlying suburb of Maputo city, that people were still using charcoal for cooking even though they had electricity for illumination.

Besides direct causes, there are also indirect causes of deforestation, such as weakness of legislation and lack of enforcement that enables people from outside the region to obtain access to the resources and fulfill their personal business interests through charcoal production within the forest sector (Sitoe et al. 2013). The Licuati thicket was kept in good condition while it was under the jurisdiction of a local leader, Augusto Santaca (Izidine et al. 2009), who died in 2009. The death of this leader, who patrolled the area, has allowed for considerably greater accessibility to the area for charcoal exploitation. Charcoal production from indigenous species (Sitoe et al. 2013; Chavana 2014) was found to be the main means of obtaining cash to fulfill basic living needs (Izidine et al. 2008; Sitoe et al. 2013) such as buying clothing and paying school fees for children.

The ongoing degradation of the Licuati thicket demonstrates clearly that weak enforcement of environmental legislation is an inherited problem that started in the colonial era but is escalating today. Therefore, there is a pressing need to improve law enforcement if biodiversity conservation is to be successful in the Mozambican part of the MCE. At present, the impact of charcoal production is two-fold: removal of individual plants to produce charcoal, and also through initiating fire that can burn the forest and surrounding areas at times uncontrollably. The rate of the Licuati thicket's degradation has increased significantly since 2013, as can be seen from a time-series comparison of satellite images (Figure 5). As yet there are no ecological studies that determine how Licuati thicket and the endemic MCE species that occur within it respond to disturbance from the impacts of wood cutting for charcoal production and subsequent fire.

The ongoing threats to the Licuati thicket are of great concern since this area holds a high number of the endemic plants as shown in the hotspot analysis (Figure 8). It is also registered as a Protected Area and, of all protected areas within the MCE, contains the largest areas of high concentration of endemic plants. If the depletion of the vegetation in the area remains unchecked, and results in the extinction of the MCE endemic species, this would mean that Mozambique does not comply with CBD Aichi targets. The loss of the MCE endemics would mean the loss of the species worldwide, as they do not occur elsewhere. Given current rates of loss, urgent interventions are needed. A multidisciplinary approach that includes developing mechanized agriculture within the area to provide employment opportunities and alleviate poverty may be a solution. An alternative to the removal of trees from LCF for charcoal production could be the establishment of plantations specifically for charcoal production in abandoned lands that have already been cleared. This would reduce the pressure on natural forests that are important natural habitats for the persistence of endemic species and also provide a sink for CO_2, which in turn reduces the impact of climate change (Cramer et al. 2004; Pan et al. 2011; Baccini et al. 2012).

4.3 Species distribution modelling

Even though KwaZulu-Natal has been botanically sampled better than southern Mozambique, both areas require more floristic surveys with particular emphasis on the MCE endemics. In poorly sampled areas modelling is an important step to predicting species' potential ranges (Williams et al. 2009). Phillips et al. (2006) suggest that Maximum Entropy Models (MaxEnt) are appropriate for poorly-studied tropical regions, which is the case for MCE.

Although there is an increasing criticism in using the Area Under the Curve (AUC) to test the performance of the model (Pearson et al. 2007; Yackulic et al. 2013), this parameter is still useful (Phillips et al. 2006; Sobek-Swant et al. 2012; Wulff et al. 2013; van Proosdij et al. 2015) in evaluating how well the models perform. Yackulic et al. (2013) suggest that when using presence-only data to run the model, an important assumption to take into consideration is that sampling is random and that the probability of detecting the individuals is constant across sites of a defined landscape. Hence, AUC was used to test performance across the models in this study assuming that sampling was random. The models show a wide range of potential habitat for the majority (eight) of the 12 modelled species (Figure 5a, b, and c). However, more fieldwork would be required to consolidate these findings and to further 'fine-tune' these models.

The models show that some species have a narrow potential suitable habitat, and these are the same species with currently known restricted ranges: *Memecylon* sp. nov. (EOO less than 2 km^2); *Empogona maputensis* (EOO 13 km^2); and *Warneckea parvifolia* (400 km^2). Given these restricted ranges, coupled with high deforestation, the three species have high threat ratings (Critically Endangered, Endangered and Endangered respectively). If the single known locality of these species is impacted upon heavily, there would not be any other source populations for regeneration of the species. Such a case exists for the Licuati thicket where habitat loss due to charcoal and fire is ongoing and becoming a major concern for species restricted to this vegetation type, such as *E. maputensis*. *Memecylon sp. nov.* is also at high risk of extinction as it is currently only known from one forest patch, which is now being cleared for charcoal production and shifting agriculture.

Raphia australis, although it is not narrowly distributed in terms of EOO (6 762 km^2) when compared to the three species mentioned above, is a habitat specialist within the MCE. This species may be prone to threats given that Mozambique is experiencing long periods of drought, which may have a direct impact on this species that is adapted to swamps with an abundance of water. Furthermore, indirect impacts are also possible and include the expansion of cultivated areas, especially for rice production, in the predominantly wetland locations where *R. australis* occurs. The models indicate that the large potential habitat for *R. australis* is within the northern part of the MCE. This area is already experiencing an expansion of commercial rice production around the flood plains of the Limpopo River. These areas are located less than 40 km from where high numbers of individuals of *R. australis* are known to occur. If the rice production programme is expanded, there is a high chance that about 40% of the suitable habitat for the species will be lost.

The identification of areas of high concentration of endemics, defined here as those areas where more than 50% of endemic and near endemic species occur, are important as they can inform conservation planning, the expansion of existing protected areas and also assist with further studies in the region (Austin 2002; Sanderson et al. 2002; Williams et al. 2009; Feeley & Silman 2011). In South Africa the areas from Ezinesh and UMkhuze, including a smaller area of Mozi, Shemula, Mbodla and Tembe Elephant Park were identified as sites of high species overlap. In Mozambique, the core priority areas were found within the Licuati Forest Reserve (LFR), including the south west portion of the Maputo Special Elephant Reserve. The significant habitat degradation for charcoal production currently occurring in Licuati, despite this area being considered protected as a 'reserve', shows that in reality very little protection is being afforded to Mozambique's coastal plain endemics. Most (10 out of 13) of the evaluated species fall within threatened categories (Vulnerable, Endangered and Critically Endangered), which is an indication that protected areas are not fulfilling their required role.

5. CONCLUSION

This study of the Maputaland endemic and near-endemic plant species sets out to understand the spatial distribution of these species and to identify areas where they are concentrated. It is the first study to combine historical specimen records from a range of herbaria with targeted field surveys to understand species distributions within the MCE. With a doubling of the number of records and increasing the known ranges of more than 50% of targeted species, this study is a major step forward in the knowledge of endemic species distributions within the MCE. It was found that the study species are distributed throughout the coastal plain of the MCE. However, the Licuati thicket in southern Maputo and the southern portion of Tembe Elephant National Park to Ezineshe were identified as areas of high concentration of the target species with above 50% showing overlapping distributions within these areas. In addition, this study revealed for the first time the high concentration of the *Raphia australis* in the northern end of the MCE, namely at Bilene Macia District and within a small portion of north-east Manhiça District.

The second objective of this study was to determine the major threats to the Maputaland endemic and near-endemic plant species. Through the completion of IUCN Red Listing assessments it was found that 10 of the 13 species assessed are threatened with extinction and one is already extinct (*Emicocarpus fissifolius*). Habitat loss due to charcoal production is the dominant threat to the majority of species, especially those whose distributions fall within forest and thicket patches of southern Mozambique. With only two of these species having being previously assessed, this study provides a significant improvement to understanding the conservation status of Maputaland's endemic plant species. However, much work remains to be done. For example, nine Maputaland coastal plain endemics were not assessed as no new field data was obtained for them during field surveys.

With only 351 species assessed for the country (MICOA 2014) and around 800 species suspected to be endemic and near-endemic (da Silva et al. 2004), Mozambique has a long way to go to achieve Target 2 of the Global Strategy for Plant Conservation (GSPC). Within the MCE, successful conservation of the Maputaland endemic plants will depend on multidisciplinary approaches with an emphasis on law enforcement and the provision of alternative sources of energy and means of subsistence.

Finally, this study aimed to identify where the priority areas are that, if protected, would best benefit conservation of the MCE endemic plants. It was found that Bilene, Macia and north east Manhiça Districts are of high priority in order to conserve *Raphia australis,* which is restricted to the swamps and flooded valleys in this region. The Licuati Forest Reserve (LFR) within Mozambique and the Tembe Elephant Park (TEP) to Ezineshe area in South Africa are of high priority to conserve the forest and thicket specialist species. While LFR and TEP are already declared protected areas, in the case of LFR lack of enforcement means that the unique biodiversity present in this reserve is not being conserved. The use of the models provided good insights about the potential suitable habitat of the species. Unfortunately, much of potential habitat highlighted as important for conservation of these endemics occurs outside of existing protected areas and overlaps with human settlement, cities, agricultural land and areas identified by the Mozambican and South African governments for new infrastructural and agricultural development.

6. FURTHER RESEARCH AND RECOMMENDATIONS

The study highlighted some gaps in the knowledge concerning the ecology of the thicket vegetation within the Licuati Forest Reserve where several major threats have been identified. Therefore, further studies are required to understand the dynamics of the thicket vegetation after disturbance, mainly by fire particularly when frequencies tend to increase in forest areas. Moreover, studies are needed to identify appropriate ways to improve legislative and law enforcement policies concerned with protected area conservation. It is also important to identify alternative means of subsistence for the communities to alleviate pressure on native species being used for charcoal production.

This study noted that the available land cover assessments for the MCE area are not adequate to quantify the extent, degree and rate of degradation in the region. Therefore, it is recommended that further studies should consider using a sequence of land cover products over a period of time to quantify degradation rates.

The models suggest a wide range of potential suitable habitat for the endemic species of the Maputaland Centre of Endemism. However, additional field surveys are needed to ground-truth the occurrence of the species throughout those areas predicted by the models. Core areas, predicted to contain more than 50% of endemics, should be the focus of ground-truthing studies. Should these area be found to contain the endemics and also be in good condition, protected area expansion into these areas is recommended.

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APPENDICES

APPENDIX A

Taxonomic notes on the selected MCE endemic and near-endemic targeted plant species

ACANTHACEAE

1. ***Dicliptera quintasii*** Lindau, Botanische Jahrbücher für Systematik 22: 121 (1897); Clarke, Flora Capensis 5:92 (1901); Balkwill *et al*., Kew Bulletin 51:44 (1996); Flora Zambesiaca 8,6:271 (2015). Type: Mozambique, Moamba District, Pessene, *Quintas* 85 (B†, holotype; C; COI).

2. ***Sclerochiton apiculatus*** Vollesen, *Kew Bulletin* 46,1: 41 (1991). Type: South Africa, Natal, Ingwavuma District, Tongoland, near Makanes Pont, *Hilliard* 4895 (K, holotype; PRE, S, SRGH, isotypes).

Sclerochiton coeruleus sensu Macnae & Kalk, A Natural History of Inhaca Island: 153 (1958); Hilliard in Notes from the Royal Botanic Gardens, Edinburgh 30:112 (1970); Ross, Flora of Natal (Botanical Survey Memoir No. 39): 324 (1973), non (Lindau) S.Moore (1911); Kew Bulletin 46,1:41 (1991).

APOCYNACEAE

3. ***Emicocarpus fissifolius*** K.Schum. & Schltr., Botanische Jahrbücher für Systematik 29: 21-22 (1901). Type: Mozambique, near Lourenço Marques (Maputo), 100 ft, 30 Nov. 1897, *Schlechter* 11535 (NBG [SAM], holotype; BR, E, GRA, HBG, K, NU, PRE, S, WAG, isotype).

Synonym: *Lobostephanus palmatus* N.E.Br. in Hooker, Icones Plantarum 27, t.2692 (1901). Type: Mozambique, Delagoa Bay (Maputo), 1893, *Junod* 52 (K, holotype; Z, isotype).

ARECACEAE

4. ***Raphia australis*** Oberm. & Strey, Bothalia 10,1:29-37 (1969). Type: Natal, Ingwavuma District, Kosi Bay area, west of Lake Amanzimnyana, 6.3 miles east of Maputa, edge of dense forest which is inundated in the rainy season, November 1967, *Strey* 7785 (PRE, holotype; NH, isotype).

Raphia vinifera, sensu Aitken, A.D. & Gale, G.W. (1921), non Beauv. in Flore d'Oware et de Bénin 1:77 (1806).

ASTERACEAE

5. ***Distephanus inhacensis*** (G.V.Pope) Boon & Glen, Bothalia 43,1:94 (2013). Type as below:

Basionym: *Vernonia inhacensis* G.V.Pope , Kew Bulletin 43:280 (1988). Type: Mozambique, Xai-Xai, Praia Sepulveda, *Barbosa & de Lemos* 7843 (K, holotype).

Distephanus inhacensis (G.V.Pope) Boon & Glen, South African Journal of Botany 94:242 (2014). *Vernonia inhacensis* G.V.Pope, Flora Zambesiaca 6,1:81 (1992).

CARYOPHYLLACEAE

6. ***Krauseola mosambicina*** (Moss) Pax & K.Hoffm., in Engler & Prantl, Die Natürlichen Pflanzenfamilien Ed. 2, 16c: 308 (1934); Flora Zambesiaca 1,2:339 (1961). Type: Mozambique, Marracuene, *Moss* 8026.(J, holotype; BM, isotype).

Basionym: *Pleiosepalum mosambicinum* Moss, Journal of Botany 69:65, t. 596 (1931). Type: as above.

CELASTRACEAE

7. ***Prionostemma delagoensis*** (Loes.) N.Hallé, Bulletin du Muséum National d'Histoire Naturelle Section B, Adansonia 3:7 (1981). Type: as below:

Basionym: *Hippocratea delagoensis* Loes., Botanische Jahrbücher für Systematik 34: 119 (1904). Type: Mozambique, Lourenço Marques, *Schlechter* 11517 (B†, holotype; BM, COI, K, PRE); in Flora Zambesiaca 2,2:406 (1966).

Hippocratea delagoensis Sim, Forest Flora and Forest Resources of Portuguese East Africa: 37, t. 30B (1909) nom. illegit. Type: Mozambique, Delagoa Bay, *Sim* 6390 (?);Flora Zambesiaca 2,2:406 (1966).

CONVOLVULACEAE

8. ***Ipomoea venosa* var. *obtusifoliola*** Verdc., Kirkia 6,1:120 (1967); Type: Mozambique, Sul do Save, Marracuene, between Lourenço Marques and Costa do Sol, Jan. 1950, *Pedro* 3844 (LMJ, holotype).

CRASSULACEAE

9. ***Crassula maputensis*** R.Fern., Boletim da Sociedade Broteriana Série 2, 52:178, t. 2: (1978); Flora Zambesiaca 7,1:13 (1983). Type: Mozambique, Maputo, on the road Salamanga-Ponta do Ouro, *A. & R. Fernandes & A. Pereira* 38 (COI, holotype; LMU, isotype).

Crassula expansa sensu Schönl., Annals of the Bolus Herbarium 2: 57 (1917) pro parte quoad specimen *Schlechter* 11534 non Dryand. (1789).

Crassula sp. sensu Mogg in Macnae & Kalk, A Natural History of Inhaca Island: 145 (1958).

EUPHORBIACEAE

10. ***Phyllanthus reticulatus* var. *orae-solis*** Radcl.-Sm., Kew Bulletin 51,2:319 (1996); Flora Zambesiaca 9,4:45 (1996). Type: Mozambique, Maputo Province, between Polana and Costa do Sol, 17 September 1947, *Pedro & Pedrógão* 1850 (PRE, holotype).

LAMIACEAE

11. ***Plectranthus psammophilus*** Codd, Bothalia 11:405 (1975); Flora of Southern Africa 28,4:156 (1985); Flora Zambesiaca 8,8:250 (2013). Type: South Africa, KwaZulu-Natal, Makatini Flats, January 1964, *Strey* 5779 (PRE, holotype; BR, K, M, NH, isotypes).

MALPIGHIACEAE

12. ***Acridocarpus natalitius*** A. Juss. **var. *linearifolius*** Launert, Boletim da Sociedade Broteriana Série 2,35:32 (1931); Flora Zambesiaca 2,1:111 (1963). Type: Mozambique, Magude, Mapulanguene, *Torre* 6564 (LISC, holotype).

MELASTOMATACEAE

13. ***Memecylon sp. nov.***, unpubl. Type material: Mozambique, Gaza, Bilene, forest surrounding M-cell tower 11 km from Bilene on road to Macia, *Burrows, J.E; Matimele, H.A.; Timberlake, J.R.; Raimondo, D. & Hoffman, M.T.* 14765 (BNRH; NU).

14. ***Warneckea parvifolia*** R.D.Stone & Ntetha, South African Journal of Botany 88:320 (2013). Type: South Africa KwaZulu-Natal, 2732 (Ubombo): Tembe Elephant Park (-AB), 3 September 1987, *M.C. Ward* 2091 (PRU, holotype; NH, isotype).

Memecylon sousae sensu A.Fern. & R.Fern., Boletim da Sociedade Broteriana, Série 2,46:67, (1972); in Flora Zambesiaca 4:228 (1978); pro parte, quoad *Gomes e Sousa* 4380 (COI, holotype).

Warneckea sousae (A.Fern. & R.Fern.) A.E. van Wyk, in Coates Palgrave: 844 (2002). Type as above.

PEDALIACEAE

15. ***Dicerocaryum forbesii*** (Decne.) A.E.van Wyk, Plants of Africa 58:119 (2003). Type as below:

Basionym: *Pretrea forbesii* Decne., Annales des Sciences Naturelles Botanique sér. 5,3:334 (1865). Type: Mozambique, 'Delagoa Africae australis', *Forbes* s.n. [34/3] (P, holotype; K, isotype).

Dicerocaryum senecioides (Klotzsch) Abels., Flora Zambesiaca 8,3:107 (1988) *pro parte*. Type: Mozambique, Boror, *Peters* s.n. (B†, holotype; CGE, lectotype).

RUBIACEAE

16. ***Empogona maputensis*** (Bridson & A.E.van Wyk) J.Tosh & Robbr., Annals of the Missouri Botanical Garden 96: 208 (2009). Type as below:

Basionym: *Tricalysia maputensis* Bridson & A.E.van Wyk., Flora Zambesiaca 5,3:475 (2003). Type: Mozambique, Matutuíne (Bela Vista), Tinonganine-Freire road, viii.1957, *Barbosa & Lemos* 7807 (LISC, holotype).

17. ***Pavetta vanwykiana*** Bridson, Kew Bulletin 56:596 (2001). Type: South Africa, KwaZulu-Natal, on road from Sodwana Bay to Ubombo, *Smook* 1310 (PRE, holotype; K, photo.).

Pavetta schumanniana sensu Garcia, Memórias Junta Investigações Ultramar, Série Botânica, 2 6:40 (1959) [Contribuições para o Conhecimento da Flora de Moçambique IV (1958)], pro parte, as to *Torre* 7465.

18. ***Psychotria amboniana* subsp. *mosambicensis*** (E.M.A.Petit) Verdc., Flora Zambesiaca 5,1:24 (1989). Type: Mozambique, between Costa do Sol and Marracuene, Mutanhane, *Balsinhas* 271 (BM; K, holotype; LMA).

Basionym: *Psychotria albidocalyx* var. *mosambicensis* Petit, Bulletin du Jardin Botanique de Bruxelles 36:83 (1966).

19. ***Psydrax fragrantissima*** (K.Schum.) Bridson, Kew Bulletin 40,4:711 (1985); Flora Zambesiaca 5,2:357 (1998).Type: as below:

Basionym: *Plectronia fragrantissima* K.Schum. in Engler, Botanische Jahrbücher 28:75 (1899); Schinz in Memoires de l'herbier Boissier. 10:68 (1900). Type: Mozambique, Maputo (Lourenço Marques), *Schlechter* 11635 (B†, holotype; BM, BR, COI, K, L, isotypes). *Canthium locuples* sensu Codd in Kirkia 1:108 (1961) pro parte, non K.Schum. (date?); *C. fragrantissimum* (K.Schum.) Cavaco, Portugaliae Acta Biologica., sér. B, 11:220 (1972); Kew Bulletin 40,4:711 (1985).

20. ***Rytigynia celastroides*** (Baill.) Verdc. **var. *australis*** Verdc., Kew Bulletin 42,1:172 (1987); Flora Zambesiaca 5,2:293 (1998). Type: Mozambique, Inhachengo, 26 Feb. 1955, *Exell et al*. 618 (LISC, holotype; BM, isotype).

21. ***Vangueria monteiroi*** (Oliv.) Lantz, Plant Systematics and Evolution 253:180 (2005).

Basionym: *Ancylanthos monteiroi* Oliv. in Hooker’s Icones Plantarum 8:7, t.1208 (1877). Type: Mozambique, Delagoa Bay, *Monteiro* 50 (K, holotype).

Synonym: *Lagynias monteiroi* (Oliv.) Bridson, Flora Zambesiaca 5,2: 241 (1998).

22. ***Zanthoxylum delagoense*** P.G.Waterman, Taxon 24,(2/3):365 (1975). Type as below:

Synonym: *Fagara schlechteri* Engler, in Botanische Jahrbücher. 46: 409 (1911); Die Pflanzenwelt Afrikas . 3, 1:750 (1915); in Engler & Prantl, Die Natürlichen Pflanzen-familien. Ed. 2 19a: 223 (1931); Flora Zambesiaca 2,1:189 (1963). Type: Mozambique, Lourenço Marques, *Schlechter* 12005 (B†; BM);

Xanthoxylum capense sensu Sim, Forest Flora and forest resources of Portuguese East Africa: 23 (1909).

Fagara capensis sensu Verdoorn in Journal. of Botany, London. 47:204 (1919) pro parte, quoad syn. *Xanthoxylon capense* (Thunb.) Harv.

APPENDIX B

Detailed conservation assessment of 13 species.

1 Raphia australis

a) Geographic range

Raphia australis, described in 1969, is a palm growing up to 16 m high and the genus is well known for having the biggest leaves of all known plants in the world (Glen 2004). The species flowers once between the age of 20 to 40 years, and then it dies two to three years after fruiting. Before this study, the natural population of the species was known from Kosi Bay in South Africa to as far north as to Bobole, in Marracuene district about 40 km north of Maputo city in Mozambique (Glen 2004). There was also a non-native subpopulation planted in Mtunzini in KwaZulu-Natal, South Africa. However, by 2015, as a result of this study and another ongoing study conducted by Alice Massingue (pers. comm.), knowledge of the range of natural *R. australis* had expanded to further north in Macia district (Figure 3), southern Mozambique, just before the Limpopo river mouth.

b) Habitat and Ecology

This very large palm occurs in swamps, peat lands and seasonally inundated dunes. Plants have pneumatophores (breathing roots) like mangroves. The plants flower once, between 20 and 40 years, and then dies three years after setting fruit. Fruit is eaten and dispersed by Palm-nut Vultures. This species has the largest leaf of any plant in the world.

c) Population

The population of *R. australis* is constituted by three subpopulations accounting for at least 5500 mature individuals' as estimated during this study. The first subpopulation occurs, in Macia and the north end of Manhiça districts in Mozambique with estimated mature individuals of nearly 4000. The second is from the Marracuene district at Bobole and between Marracuene village and Costa do Sol in Mozambique with estimated number of mature individuals at 500. The third subpopulation occurs in north east KwaZulu-Natal in South Africa around Kosi Bay and KwaNgwanase with more than 1000 mature individuals. There is also an introduced subpopulation at Mutunzini, in South Africa, which according to Scott-Shaw (1999) was planted in 1915. There are a number of other small stands of individuals that have been planted across KwaZulu-Natal but only the population at Kosi Bay occurs within the natural range of this species. All planted individuals including those at Mtunzini are not included in this assessment. This is because the conservation assessment under IUCN criteria does not include non-native populations (IUCN 2012).

d) Threats

R. australis is an iconic species restricted to swamps and inundated valleys. In southern Mozambique, the species' habitat is under pressure due to subsistence farming in the Bobole area. The subsistence farming techniques in swamps include creation of drainage channels, thereby increasing the runoff of water which in turn impacts negatively on the seedling recruitment. In addition, there is an increasingly high likelihood that the coastal plain around north east Bilene may become Chinese concessions for rice production. In fact, the rice production by Chinese has already started within the Limpopo River flats area which is less than 50 km from locations where *R. australis* occur. If the concessions are expanded from Limpopo River flats southward to Bilene, it is probable that at least three locations of the species will be lost. This would represent a potential loss of about 40% of the known native population.

e) Conservation

The plants at Kosi Bay are not under threat and are contained within a conservation area, although local use of the plants is allowed. The 12 ha Bobole Special Reserve 40 km north of Maputo, was proclaimed to protect this species however subsistence farming still occurs here. All other subpopulations in Mozambique are not protected.

f) Rationale

R. australis is an endemic to the MCE, occupying 6762.75 km^2 of EOO, known from a total of three subpopulations. There are two subpopulations in Mozambique, and one in South Africa. This species is restricted to swamps and seasonally inundated dunes with an AOO of 56 km^2. There are seven locations three of which are experiencing ongoing decline in habitat quality due to subsistence farming and urban housing development. A further 30 - 40% of the population is predicted to be lost due to expected expansion of large scale rice cultivation in concessions provided to the Chinese by the Mozambican government. Taking into consideration the increasing threat, *R. australis* has been upgraded from Data Deficient (DD) to Vulnerable A3c; B1ab (iii)+2ab(iii).

2 Memecylon sp. nov.

A review of African members of the genera *Memecylon* and *Warneckea* by R.D.Stone, using DNA information, has shown that this taxon is undescribed and now awaits full description (Burrows, pers. comm). Flowering material collected during this study has provided the essential first flowering material that will enable it to now receive a name.

a) Geographic range

Memecylon sp. nov., is an endemic to the MCE, currently known from one location in Bilene, Macia district in southern Mozambique. The species occurs in a forest patch of good condition, 0.26 km^2 in area.

b) Habitat and Ecology

This species is restricted to a tall coastal forest on sands of ancient dunes. This forest patch contains high number of lianas and good leave litter on the ground. The ground layer include species such as *Zamioculcas zamiofolia, Coleotrype natalensis, Microsorum scolopendria, Oplismenus hirtellus, Sansevieria* sp.

c) Population

There is only one subpopulation known from Macia District in Gaza Province, Mozambique. In 2015, 21 individuals were counted in an area less than 0.005 km^2. It was observed that the individuals of *Memecylon* sp nov. are scattered within this forest patch preferably in sites with tall trees. Therefore, it can be estimated that the entire population is not more than 250 individuals of the species within its EOO of 0.005 km^2.

d) Threats

Because this forest patch has been kept as a sacred place, any kind of exploitation was historically prohibited. The surrounding area has been completely transformed due to shifting subsistence farming and charcoal exploitation. In 2004 a cellphone tower was erected in the centre of the forest patch and since then exploitation of the sacred forest has begun in the form of burning forest margins for charcoal production and for later farming by local communities.

e) Rationale

A new species discovered in 2009 and in the process of being scientifically described, is known from a single forest patch (EOO and AOO ≤ 0.005). Although previous protected as a sacred forest by surrounding communities, the increasing demand for wood to turn into charcoal and land for agriculture has resulted in sections of the forest being burnt. The increasing human population in the surrounding areas and ongoing escalation in demand for agricultural land and wood for charcoal production, is highly likely to deplete the single known location of the species in a short time (± 10 years). As a result, *Memecylon* sp. nov. which has a suspected generation length of 40 years, has been listed as Critically Endangered A3cd; B1ab(i,ii,iii,v)+2b(iii); C2a(ii).

3 Acridocarpus natalitius var. *linearifolius*

a) Geographic range

Based on the literature (Launert 1963; Boon 2010), herbarium specimens and field surveys conducted during this study, the species is known to occur from Hluhluwe Game Reserve, KwaZulu-Natal South Africa to Massingir Gaza Province in southern Mozambique. It is concentrated along the coastline throughout its range, although it has been seen occasionally at high altitude.

b) Habitat and ecology

This taxon is scattered in bushveld, woodland, grassland and sand forest (Boon 2010) throughout its known range. It recruits from seed (Boon 2010). During field survey it was observed to be present within pristine patches of sand forest but, also it was present in areas that were used in the past for subsistence farming, grazing, and timber exploitation. This may suggest that the specie can cope with some level of disturbance if this disturbance has ceased.

c) Population size

Acridocarpus natalitius var. *linearifolius* occurs as sparsely scattered individuals throughout suitable habitat within its range. In the southern Maputo province of Mozambique from Licuati

Forest Reserve to Ponta do Ouro area, 56 individuals were counted through following the roads, which comprise less than 5% of the entire area. Therefore, it can be estimated that above 1000 individuals occur within the area from Licuati Forest Reserve to Ponta do Ouro. Consequently, it has been estimated that fewer than 2000 individuals occur in the Maputaland coastal plain of southern Mozambique.

In South Africa, no studies were found that quantify the number of individuals within the species range. However, several studies describing the vegetation communities in northern KwaZulu-Natal (Mathews et al. 1999; Gaugris et al. 2004; Gaugris & van Rooyen, 2007; Boon, 2010) noted the presence of this taxon. From these studies it can be inferred that around 2000 individuals occur within KwaZulu-Natal South Africa. The overall population is thus suspected to be less than 10000 individuals.

d) Threats

Overall there is ongoing development and an increase in land demand for human settlement, and food production in both countries, South Africa and Mozambique, where the taxon occurs. Activities such as large scale food production, urbanization and industrialization can be considered a severe threat to the survival of the taxon as they effectively occupy its suitable habitat. Therefore, with an expected increase in demand for agricultural and urban land use, it can be predicted that 20% of the entire population may be lost by 2040. During field surveys in 2015 this taxon was found both in pristine and marginally disturbed habitats. This may suggest that the species can cope if the disturbance is removed. However observation showed that, with ongoing crop cultivation and urban development, this species cannot survive. In addition, the roots of the species are used for medicinal purpose (Williams et al. 2001; Philander 2011). Even though this species can cope with disturbance, the removal of roots can have a serious impact on survival. The taxon is harvested to fulfill the local medicinal needs at the community level. In addition, it has been recorded within different markets in South Africa where medicinal plants are sold (Williams et al. 2001). Therefore, this suggests that there is an ongoing trade of the species to supply the markets which is inferred to be causing ongoing decline. About 10% of the population is estimated to have declined over the past 45 years (generation length 30 years) due to medicinal harvesting and habitat transformation.

e) Conservation

The species is conserved within Tembe Elephant Park, Hluhluwe Game Reserve, Tshanini Game Reserve and iSimangaliso Wetland Park in South Africa and at the Licuati Forest Reserve, in Mozambique.

f) Rationale

Acridocarpus natalitius var. *linearifolius* is an endemic to the MCE and occupies an EOO of 23,234 km^2. This taxon occurs as sparsely scattered individuals throughout the Maputaland coastal plain and also a few sporadic occurrences have been recorded further inland on sandy soils at higher altitude. Surveys within southern Mozambique have confirmed the sparse distribution of this taxon and allow an extrapolation of the population to fewer than 10 000 individuals. The roots of *Acridocarpus natalitius var. linearifolius* have been documented as being used for medicine (Williams et al. 2001). Medicinal use combined with past habitat transformation has led to a 10% decline in the population over the past 45 years with future loss to urban and agricultural development suspected to cause a further 20% of the population to be lost by 2040 (generation length 30 years). Therefore, the species has been assessed as Vulnerable under criterion A4c; C1.

4 Dicerocaryum forbesii

a) Geographic range

Findings from herbarium data, the field survey conducted during this project and the study by van Wyk & Condy (2003), show that the species is known from Ezineshe, central KwaZulu-Natal in South Africa to Matutuine District, southern Mozambique.

b) Habitat and ecology

Dicerocaryum forbesii is a prostrate herb with perennial taproot (van Wyk & Condy, 2003) from which the species produces radiating stems appressed to the ground. The species occur preferentially on the characteristic pale sandy soils of the Maputaland coastline. It is found in open wooded coastal grassland on bare sands with full sun access. However, the species is also often found within disturbed areas such as old farm and grazing sites (van Wyk & Condy, 2003). Observations in the field during the survey in 2015 the species was found occurring in wooded grassland on pale sand with thicket clumps with species such as *Strychnos madagascariensis*, *Terminalia sericea*, including some geophytes such as *Crinum delagoensis*, *Scadoxus* spp. Also the species was found occurring on the clay soils in an open grassland where grazing and subsistence cultivation takes place by the water drainage. *Dicerocaryum forbesii*, reproduces by seeds. The seeds have two persistent spikes which can penetrate hoofs of animals, including humans on bare foot or soft shoes. This process disperses the seed throughout the species range however there is a lack of studies on this matter (van Wyk & Condy 2003).

c) Population

The species is known from two subpopulations within its range. Observations of the species during this study in and around Licuati Forest Reserve in the Matutuine District showed that *Dicerocaryum forbesii* prefers to grow in open areas and thrives in areas that have been previously disturbed. Even in areas under current agricultural use, e.g. areas been used for livestock farming had high numbers of individuals. As there is ongoing disturbance and opening up of forest and thicket within this species range and an increase in the number of abandoned farms this taxon is suspected to be increasing its population size.

d) Threats

This species is used for medicinal purposes and hygiene such as soap or shampoo for hair cleaning (van Wyk & Condy, 2003). However, there is no information on the negative impact of use for the long term persistence of the species. The predominant land uses in Northern KwaZulu-Natal and Southern Mozambique of shifting agriculture and clearing of forests for wood or charcoal production are all suspected to favour this species. The only threat it thus faces is complete habitat transformation to urban development industrialization, opening of new roads and commercial agriculture. While these land uses are slowly increasing they are not suspected to cover more than 3% of this species range at this stage.

e) Rationale

Dicerocaryum forbesii is an endemic to the Maputaland Centre of Endemism (EOO 182.9 km^2), known from six locations, all of them falling within Northern KwaZulu-Natal and the LFR area of Southern Mozambique. Despite being a restricted endemic this taxon favours disturbance and opening up of the forest areas and the dominant land uses of shifting agriculture and cutting of forest for charcoal and wood are increasing available habitat for this taxon. It is therefore listed as Least Concern.

5 Distephanus inhacensis

a) Geographic range

Distephanus inhacensis is known from Zimbali Dune Forest (Swelankomo & Manning, 2014) in KwaZulu-Natal, South Africa to as far north as Bilene, in Macia District, Gaza Province in southern Mozambique.

b) Habitat and ecology

Distephanus inhacensis is a woody climber or scrambling species occuring on coastal bush as well as coastal forest of the coastal plain (Swelankomo & Manning 2014) throughout the species range. According to Swelankomo and Manning (2014), the leaves of individuals' occurring on coastal dunes are glabrous and somewhat succulent compared to the individuals inland. The species occur on well drained sand soil of recent and ancient formation.

c) Population

Distephanus inhacensis is known from three subpopulations, one in South Africa within the Saint Lucia Estuary area and the Sodwana Bay National Park. The other two subpopulations are known from southern Mozambique, one at the Licuati Forest Reserve in Maputo Province and the second in Bilene, Macia District in Gaza Province. There is no information available in terms of population size in KwaZulu-Natal. However, based on the extension of forest with tall trees along the coastline, which suits the species well, it can be suspected that more than 2000 individuals are present.

In Mozambique, through field surveys in 2015, 23 individuals were counted. Counting was undertaken by walking randomly through accessible parts of the forests. This counting may have covered less than 5% of the entire suitable habitat in Mozambique. Therefore, it can be estimated that more than 3000 individuals can be found within the three subpopulations in Mozambique. Hence, it can be possible that the entire *Distephanus inhacensis* population is of more than 5000 individuals.

d) Threats

In both, Mozambique and South Africa, there is ongoing development resulting in deforestation of large areas suitable for the species. With ongoing development through urbanization, increasing infrastructure, and increased forestry resource exploitation, this species habitat is under pressure. Overall, subpopulations that occur outside protected and less enforced areas are likely to be under threats. In South Africa the species distribution overlaps with some protected areas such as Sodwana National Park, Mabibi Nature Reserve and Tembe Elephant Park. In Mozambique, the species is found within the LFR and the sacred forest patch in Bilene. The LFR established in 1943 (Gomes e Sousa, 1968) with 50,000 hectares of forest and thicket, had been reduced to 19,000 hectares in 1968. This resulted from concessions for timber exploitation, agriculture and livestock despite the Licuati Forest being a reserve. The degradation of habitat at Licuati is suspected to have caused a decline of around 10% to the overall population since 1943. Over the past five years, Licuati Thicket vegetation has become one of the nearest source to Maputo of woody trees and shrubs for charcoal. With 80% of Mozambique's population depending on charcoal as a source of energy, and all wood to make charcoal coming from indigenous vegetation with little indication of this trend changing (Chavana, 2014), further loss and severe degradation of at least 90% of the dry and coastal forest in southern coastline in Mozambique is expected to occur within the next 100 years. Therefore, a further loss of 50% of the species is expected to occur for the entire population.

e) Rationale

D.inhacensis is an endemic to the MCE, and it has an EOO of 9789 km^2. The AOO calculated for known subpopulations is 56 km^2. There may still be other suitable habitat that has not yet been surveyed however, the coastal and dry forest habitat of this species within the Maputaland plain is limited and the maximum AOO is not likely to be more than 300 km^2. The species is known from 10 locations throughout its range in South Africa, KwaZulu-Natal, and in southern Mozambique up to Gaza province. Although the species occur in some well protected areas such as Sodwana Bay National Park, Tembe Elephant Park, more than half of the population occur within areas susceptible to transformation. There is ongoing pressure for timber, and charcoal extraction within the LFR including the dry forest around as far south as Ponta do Ouro. In addition, tourism expansion around Ponta do Ouro is removing the dunes where the species is found. This is long lived species with a generation length of at least 40 years. Past defrostation has led to 10% loss of the population over the past 80 years. A further 50% of the population is predicted to be lost due to deforestation in southern Mozambique over the next 100 years. Taking this into consideration, the species has been assessed as Endangered A4c; B2ab(i, ii, iii, v).

6 Empogana maputensis

a) Geographic range

Currently the specie is known from the Licuati Forest Reserve (LFR) in Matutuine District southern Mozambique.

b) Habitat and ecology

Empogona maputensis is restricted to the Licuati Thicket which is a "short" forest on sand ancient dunes. These soils are well drained and it is located within 100 km from the coastline. Moisture that maintains these vegetation types is obtained from south north winds that carry coastal moisture as well as from seasonal rain. Moisture availability in these systems is restricted to the superficial soil layer to a depth of only 80 cm. The soils in these systems are nutrient poor and with limited moisture the characteristic woody species including *Empogona maputensis* are slow growing and long lived. The species reproduces by seeds.

c) Population

The number of individuals counted within the LFR area during surveys in 2015 resulted in 53 individuals. This was done following the roads cutting through the Licuati Thicket which counts for about 5% of the entire area. As this specie is inconspicuous small plant, there is a high chance of it not being detected during surveys. Thus, it is suspected that *Empogona maputensis* is likely to occur throughout the thicket vegetation of the LFR, hence it is expected that over 1500 individuals are present across the species known range.

d) Threats

Currently the only known population is in Mozambique in Licuati thicket. The Licuati thicket is experiencing ongoing degradation of habitat due to charcoal production. Charcoal production involves cutting of thick woody stems, piling these stems and covering them with sand and grass and then igniting these traditional charcoal kilns. In the process of cutting and cleaning large stems many small branches and twigs are left in the forest, these dry out and create a source of fuel for fire. The combination of a seasonal drought, with increased fuel from branches left during charcoal production as well as increased ignition sources from lighting of charcoal kilns is resulting in fires occurring within the Licuati Thicket. During 2015 large areas of Licuati Thicket were observed to have burnt. There are no historical records or observations of this vegetation type burning. At this stage, it is not known if this vegetation type can survive and recover from fire, however the slow growing nature of species within this system suggests that fire and cutting for charcoal will result in severe habitat degradation and possibly an ecological shift into grassy savannas found in previously disturbed farmed areas around Licuati.

Historically timber concessions and agricultural and livestock rangeland concessions were issued for the Licuati area despite this being a forest reserve due to unclear boundary definitions (Gomes e Sousa 1968) of where the actual reserve was situated. This resulted in a decline from 50 000 ha of forest and thicket in 1943 to 19 000 ha in 1968 (Gomes de Sousa, 1968).

The degradation of habitat at Licuati is suspected to have caused a decline of around 20-30% to the overall population since 1943. Over the past five years Licuati Thicket has become one of the nearest sources to Maputo of woody trees and shrubs for charcoal. With 80% of Mozambique's population depending on charcoal as a source of energy, and all wood to make charcoal coming from indigenous vegetation with little indication of this trend changing (Chavana, 2014), further loss and severe degradation of at least 80% of the Licuati thicket is expected to occur within the next 25 years. This is projected to result in a 40% loss to the population of *Empogona maputensis*.

e) Rationale

Empogona maputensis is an endemic to the MCE (EOO 151 km^2, AOO 138 km^2) known from only two locations at the LFR in Maputo province southern Mozambique where it occurs in the understory of the Licuati Thicket vegetation. There is severe ongoing habitat degradation due to charcoal production (Izidine et al. 2008). As one of the closest sources of charcoal for Maputo, Licuati Thicket is suspected to be under severe ongoing and future pressure. Past loss and degradation of habitat at Licuati due to timber and agriculture concessions (Gomes e Sousa, 1968), as well as harvesting is suspected to have resulted in 20% loss to the population. Between 1973 and 2033 a decline of 60% of the population is suspected to occur. Therefore, *Empogona maputensis* has been assessed as Endangered A4d; B1ab (i, ii, iii, v) + 2ab (i, ii, iii, v).

7 Pavetta vanwykiana

a) Geographic range

The species is known from uMkhuze Game Reserve in KwaZulu-Natal, South Africa northwards through Ndumo Game Reserve including Tembe Elephant Park to as far as the LFR in Maputo Province southern Mozambique (Boon 2010).

b) Habitat and ecology

Pavetta vanwykiana's is known as a geoxylic suffrutex occurring in colonies (Boon, 2010). The species habitat is known to be an open woodland, sand forest or thornveld on sandy soils (Bridson, 2001; Boon, 2010 & Graham et al. 2012). The soils of the species habitat are well drained soils of ancient dune formation occurring inland about 100 km of the coastline. Being geoxylic suffrutex species, *Pavetta vanwykiana* has subterranean woody axes. Overall, suffrutex are species with annual or short-lived aerial parts but with large subterranean rootstock (Vollesen, 1981). Therefore, *Pavetta vanwykiana* is adapted to cope with fire as it has underground woody axes. Based on the observations during the field survey in 2015, the species recruits from the underground woody axes.

c) Population

There are in total four subpopulations of those one is in southern Mozambique and three, in South Africa. The subpopulation in Mozambique is found in the LFR at Santaca area, and in the Licuati Thicket patch. Although there was a collection by *Correia & Marques* 1353 which was collected in Manhiça District, Maputo Province, southern Mozambique (Bridson 2001), it was not included for the purpose of this assessment as the location has been transformed due to urbanization into what is now known as Manhiça Municipality. Across the entire range of the species in southern Mozambique there is no accurate information in terms of the number of extant individuals with only 12 individuals counted during surveys in the LFR area as part of the fieldwork for this study.

The subpopulations in South Africa are all within the KwaZulu-Natal Province. Of the three subpopulations, the first is found in the UMkhuze Game Reserve, second in Phelandaba area and, the third falls within the Ndumo Game Reserve and Tembe National Park. There is no information on the size of the subpopulations in South Africa

d) Threats

Habitat degradation is the measure threat for *Pavetta vanwykiana*. Although the species is known to occur in both protected areas (UMkhuze Game Reserve, Ndumo Game Reserve, Tembe Elephant Park, and the Licuati Forest Reserve) and non-protected areas, ongoing rapid development especially in southern Mozambique is threatening to continuously reduce the species suitable habitat. The protected areas that fall within South Africa's boundaries are known to be well enforced. However, the human encroachment together with development initiatives such as settlement, mechanized farming, opening of new roads are putting pressure on these areas. Graham et al. (2012) noted that some areas of sand forests that are found between Mbazwana-Gezisa are experiencing ongoing degradation due to human settlement.

In Mozambique, the species is known from the Licuati Forest Reserve. This area has been under ongoing degradation due to charcoal production, shifting agriculture, human settlement, as well as building of infrastructure of new industry. This is expected to continue to result in loss of suitable habitat for *Pavetta vanwykiana*.

e) Rationale

Pavetta vanwykiana is an endemic to the MCE. The species occupies an EOO of 4450 km^2 and it is known from four subpopulations and eight locations. Mozambique as well as South Africa, where the species occurs, are developing countries and there is ongoing conversion of this taxon’s habitat for charcoal production, shifting agriculture, human settlement, as well as building of infrastructure for new industry. This species thus qualifies to Vulnerable B1b (ii, iii,iv,v).

8 Psydrax fragrantissima

a) Geogranphic range

Psydrax fragrantissima is known to occur in KwaZulu-Natal to as far north as to Maputo Province in southern Mozambique (Bridson, 1985; Coates Palgrave, 2002). It is known from four locations: Tembe Elephant Park and Mbazwana District in South Africa and Licuati Forest reserve and Marracuene District in southern Mozambique.

b) Habitat and ecology

The species is restricted to sand forest and thicket vegetation type on sandy soils of lower elevation (Coates Palgrave, 2002; Boon, 2010). Occasionally the species has been found in woodland (Coates Palgrave, 2002). The Licuati thicket and sand forest are on well drained soils of ancient dune formation that occur inland within 100 km of the coastline. The south-north windy supplies the moiture that mantains the thicket vegetation together with seasonal rain (Izidine et al. 2003). *Psydrax fragrantissima* is among the characteristic species of sand forest (Kirkwood & Midgley, 1999) and thicket vegetation. This vegetation type is found on poor nutrient soils. The species in the thicket vegetation type, including *Psydrax fragrantissima*, are shallowly rooted. This suggests that the species in thicket on sandy soil is adapted to cope with limited moisture availability. The adaptation includes a slow growing life form.

c) Population

There are four known subpopulations, two from KwaZulu-Natal at Mbazwana District and Tembe Elephant Park in South Africa, and the other two are from Maputo Province at the LFR and Marracuene District in Mozambique. The number of individual is less known throughout the species range however, counting during this study resulted in 250 individuals in the LFR. Having followed the roads cutting through the Licuati Thicket, it can be estimated that nearly 5% of the area was covered. Therefore, it is believed that there is a minimum of 3000 individuals in the Licuati Thicket vegetation. This is sustained by the fact that this species is common within the Thicket vegetation type. Kirkwood and Midgley (1999) suggest that *Psydrax fragrantissima* is one of the characteristic species of dry forest and sand forest. Hence, it is likely that a minimum of 2000 individuals can be found within the two subpopulations in South Africa. For this reason, it can be suspected that the entire population of the species is suspected to be between 5000 and 10000 individuals throughout its known range.

d) Threats

The majority of currently known subpopulations of *Psydrax fragrantissima* in South Africa occurs within the protected area at the Tembe Elephant Park. In Mozambique the species is also highly concentrated within the LFR where the thicket vegetation occurs. However, the Licuati Thicket is experiencing ongoing degradation due to unsustainable exploitation (Izidine et al. 2008) of forestry resources with great emphases to charcoal. During 2015 large areas of the Licuiti Thicket were observed to have burnt. The slow growing nature of the species (generation length at least 50 years) suggests that fire and cutting for charcoal will result in severe declines as a result of habitat degradation and possibly an ecological shift into grassy savannas found in previously disturbed farmed areas around Licuati.

The degradation of habitat at Licuati is suspected to have caused a decline of around 20% to the overall population since 1943. Over the past five years Licuati Thicket has become one of the nearest sources to Maputo of woody trees and shrubs for charcoal. With 80% of Mozambique's population depending on charcoal as a source of energy, and all wood to make charcoal coming from indigenous vegetation with little indication of this trend changing (Chavana, 2014), further loss and severe degradation of at least 80% of the Licuati thicket is expected to occur within the next 25 years. As the Tembe Elephant Park subpopulation is not suspected to be declining an overall decline of around 50 % of the population is thus suspected to occur.

e) Rationale

Psydrax fragrantissima is an endemic to the MCE. This species, with an EOO 6501 km^2, is known from 10 locations. Although well conserved in South Africa the main part of the population occurs in the LFR where there is severe ongoing habitat degradation due to charcoal production. As one of the closest sources of charcoal for Maputo, Licuati Thicket is suspected to be under severe ongoing and future pressure with 80% of the Licuati subpopulation likely to be lost by 2040. Relating to an overall loss to the entire population of 50%. Past loss and degradation of habitat at the LFR due to timber and agriculture concessions, as well as harvesting is suspected to have resulted in 20% loss to the overall population. Between 1943 and 2040 a decline of 70% of the population is expected. This is a slow growing resprouting species with a minimum generation length of 50 years. Therefore, the specie is assessed as Endangered A3c+4c.

9 Warneckea parvifolia

a) Geographic range

Known from two subpopulations one from Tembe Elephant Park in northeastern KwaZulu-Natal South Africa and the second in Licuati Forest Reserve in southern Mozambique (Stone & Ntetha, 2013).

b) Habitat and ecology

This species is restricted to "short" Sand forest in northern KwaZulu-Natal (Stone & Ntetha, 2013) and Licuati Thicket in southern Mozambique. Both these vegetation types occur on well drained soils of ancient dune formation that occur inland within a 100 kms of the coastline. Moisture that maintains these vegetation types is obtained from south north winds that carry coastal moisture as well as from seasonal rain. Moisture availability in these systems is restricted to the superficial soil layer to a depth of only 80 cm. Characteristic species within these vegetation types, including *Warneckea parvifolia*, are shallowly rooted. The soils in these systems are nutrient poor and with limited moisture the characteristic woody species including *Warneckea parvifolia* are slow growing and long lived.

c) Population

There are two subpopulations known, one from Tembe Elephant Park in northern KwaZulu Natal and one from the LFR in southern Mozambique. The number of individuals in the Tembe subpopulation is unknown but Stone and Ntetha 2013, note that plants are locally common around Sihangwane within Tembe. A minimum of 2000 individuals are likely to occur at Tembe. Field surveys during this study resulted in 290 individuals being counted at LFR. This species is characteristic of the Licuati Thicket and occurs throughout the areas where the thicket is still in pristine condition. It is suspected that there are over 3000 individuals occurring at the LFR. The overall population is suspected to be more than 5000 individuals.

d) Threats

The population in South Africa in Tembe Elephant Park occurs within a protected are and is less likely to be threatened. In Mozambique the only subpopulation at the LFR is experiencing ongoing degradation of habitat due to charcoal. The degradation of habitat at the LFR is suspected to have caused a decline of around 20% to the overall population since 1943. As the Tembe Elephant Park subpopulation is not suspected to be declining an overall decline of around 50 % of the population is thus suspected to occur.

e) Rationale

Warneckea parvifolia is an endemic to the MCE (EOO 400 km^2), known from two locations, one in Tembe Elephant Park, KwaZulu-Natal South Africa and the other at the LFR in Maputo province southern Mozambique. Although well conserved in South Africa the main part of the population occurs in the LFR where there is severe ongoing habitat degradation due to charcoal production. As one of the closest sources of charcoal for Maputo, the Licuati Thicket is suspected to be under severe ongoing and future pressure with 80% of the Licuati subpopulation likely to be lost by 2040. Relating to an overall loss to the entire population of 50%. Past loss and degradation of habitat at the LFR due to timber and agriculture concessions, as well as harvesting is suspected to have resulted in 20% loss to the overall population. Between 1943 and 2043 a decline of 70% of the population is expected. *Warneckea parvifolia* is a long-lived slow growing resprouting species with a minimum generation length of 100 years, it has therefore qualifies for a listing of Endangered A3c+4c; B1ab (i,ii,iii,v)+2b(ii,iii,v).

10 Vangueria monteiroi

a) Geographic range

The species is known from Mphakatini, KwaZulu-Natal in South Africa to Gaza Province in southern Mozambique.

b) Habitat and ecology

This species is scatted in bushveld, coastal and dune forest (Coates Palgrave 2002; Boon 2010) across its known range. There is no information on the species is recruitment but it can be suspected that it recruits from seeds. Birds and other animals play an important role on dispersing the seeds as they feed on fruits of the species (Boon 2010). During the field visit it was observed that the species is common in areas where subsistence farming happened in the past. The species was also seen in areas where grazing and timber exploitation is taking place. From this observation it can be inferred that the species is likely to cope if the disturbance is removed. *Vangueria monteiroi* has a generation length of 15 years.

c) Population

There are four subpopulations currently known scatted throughout the species range. Two subpopulations one from South Africa at Tembe-Ndumo corridor area and a second at the Mbazwana District stretching all the way up to Kosi Bay. Another two subpopulations are found in Mozambique, one at the Licuati Forest Reserve and another, around Bilene in Macia District, Gaza Province. Subpopulations are inferred from herbarium specimens, literature (e.g. Bridson 1998; Boon 2010), and field survey conducted during this study. Surveys of *Vangueria monteiroi* in the Bilene area of Macia District and at the Licuati Forest Reserve area in Mozambique during 2015, indicated that this species occurs in previously disturbed habitats (areas that have been cut for charcoal production and where land was cleared in the past for agriculture and then left to recover). As there is extensive degraded woodland habitat across Southern Mozambique and also in northern Kwa-Zulu Natal the population of this taxon is expected to be extensive.

d) Threats

Both countries, Mozambique and South Africa, where the species' occurs are developing countries. For the last 30 years there have been a rapid increase in land use for urbanization, industrialization, opening of new roads and an increase on agriculture including afforestation. These land uses that occupy the land completely, such as food production, urbanization, industrialization, opening of new roads, can be considered severe to the survival of the species as they remove the species' habitat completely. However at this stage not more than 10% of this taxon's habitat has been irreversibly transformed. The majority of this species range (over 80% falls within Mozambique). As it is able to survive moderate disturbance, the current predominant land use of charcoal production and shifting agriculture that results in degraded woodlands, is favoring the occurrence of this species and it is likely increasing.

e) Conservation

The species is found in some locations that fall within protected areas such as Tembe Elephant Park, Ndumo Game Reserve and Licuati Forest Reserve. However, the Licuati Forest Reserve, in Mozambique, is under pressure due to human encroachment, charcoal production which becomes fire ignition for the vegetation threatening the species that are not fire adapted. Currently, there is no information on whether *Vangueria monteiroi* is adapted to fire.

f) Rationale

Vangueria monteiroi is endemic to the MCE and it has an EOO of 10033 km^2. The species occurs as sparsely scattered individuals in bushveld, coastal and sand dune forest throughout its known range and appears to be able to survive well in areas that have previously been disturbed. With the majority of this species habitat occurring outside of protected areas where the predominant land use is subsistence agriculture and where there is a high dependence of fuel from forests (wood and charcoal), there is extensive degradation of its habitat taking place. Field surveys conducted as part of this study indicate that this species is able to survive moderate disturbance and with ongoing woodland and forest degradation its habitat is likely to be increasing. Therefore, it was found appropriate to list the species under Least Concern (LC).

11 Sclerochiton apiculatus

a) Geographic range

Sclerochiton apiculatus is known from four subpopulations. Of those, two are in South Africa, KwaZulu-Natal from Mbazwana and from Tembe Elephant Park. The other two, are found in southern Mozambique where one of them is at the LFR, in southern Maputo Province, and another at Manhiça District which is at northern east Maputo Province. Individuals of these subpopulations occur at eight different locations.

b) Habitat and ecology:

The species is known to occur in dry semi deciduous coastal forest (sand forest) as well as in thicket and riverine forest of low altitude (Vollesen 1991; Boon 2010). This species occurs in the Maputaland lower level coastal plain with well drained sandy soils. Boon (2010) suggests that the species is easily grown but it is not clear how it recruits either by seeds or stems. In addition, there is no information about fire impact on the species however, it can be suspected that *Sclerochiton apiculatus* being a forestry species, cannot cope with fire.

c) Population

There are four subpopulations, of those the first is found around Sibhoweni area and the second at the Tembe Elephant Park, both in KwaZulu-Natal, South Africa. The third is located within the LFR and the fourth is at Chinhanguanine in Manhiça District, both Mozambican subpopulations are in Maputo Province, Mozambique (Vollesen, 1991). In both countries, Mozambique and South Africa, there is no information on the size of the population.

d) Threats

Individuals of this species are declining due to ongoing removal of suitable habitat of the species due to urbanization, building of new infrastructures as a result of development, food production and opening of new roads. There is extensive degradation of this species habitat due to shifting agriculture and deforestation due to collecting fuel wood and producing charcoal. Charcoal production is causing severe habitat degradation in Mozambique, as it is the only means of generating cash for the majority of the Mozambican population who otherwise largely depend on subsistence farming. Charcoal was found to be the main means of obtaining cash to fulfill basic living needs (Izidine et al. 2008) such as clothing, and paying school fees for children. With charcoal being the main source of fuel for Mozambicans, and no indication of Mozambique's government providing other sources of fuel, the trend of destruction of forests and thicket for charcoal production is expected to increase.

e) Conservation

The species occurs in protected areas in Tembe Elephant Park, in South Africa and, at the Licuati Forest Reserve in Mozambique.

f) Rationale

Sclerochiton apiculatus is an endemic to the MCE. The species occupies a limited EOO of 3626 km^2 and it is known from eight locations. The ongoing development and habitat degradation in both Mozambique and South Africa, is increasingly reducing suitable habitat of this species. Development includes expansion of urban areas, increase in land allocation for food production, human settlement, and building of new infrastructures. Habitat degradation in the form of deforestation for fuel and charcoal production is causing rapid loss of this species habitat particularly in Mozambique. *Sclerochiton apiculatus* qualifies as Vulnerable under criteria B1ab(ii,iii,v) + 2ab(ii,iii,v).

12 Zanthoxylum delagoense

a) Geographic range

Zanthoxylum delagoense is known only from southern Mozambique (Coates Palgrave, 1977, 2002). The species has been recorded from Matutuine District in southern Maputo Province northwards to as far as Pomene in Massinga District, Inhambane Province.

b) Habitat and Ecology:

The species is a shrub to medium tree which occurs in coastal dune forest (Coates Palgrave, 1977, 2002), and in dry forest located within 100 km from the coast on well drained sandy soils. This species is suspected to have a generation length of 60 years.

c) Population

There is no study that has attempted to quantify the species population. Records gathered from herbarium specimens and field survey, indicate that there are at least six subpopulations. The sub-populations are found in the LFR, Inhaca Island, Marracuene District in Maputo Province and, Xai-Xai District in Gaza Province and, Zavala (Quissico) District and Pomene at Massinga District, in Inhambane Province. During the field work conducted in southern Mozambique, 10 individuals were counted from Ponta do Ouro to Limpopo River. Coastal forests of Inhambane Province were not targeted for this study, therefore much coastal forest areas remain to be surveyed. The species seems to be scattered throughout its range occurring as stands of only a few individuals.

d) Threats

This species is used as building material, and given that *Zanthoxylum delagoense* is restricted to lower level coastal plain of southern Mozambique where there is high concentration of human population, it is suspected to be declining both as a result of direct use and due to its habitat being degraded and transformed. Habitat transformation for human settlement, urbanization, food and fuel production is expected to increase as the human population rises. The available information (e.g. Gomes e Sousa, 1968) suggests that areas such as the LFR have been reduced by 62% from 1943 to 1968. This trend can be extrapolated to the entire southern Mozambique. Therefore, it can be estimated that from 1943 to 2015 the species has lost more than 60% of its suitable habitat. Due to this species patchy occurrence in suitable habitat the overall habitat degradation is suspected to have caused a decline of ca. 15% of the population. With ongoing habitat degradation due to charcoal production and subsistence farming in southern Mozambique, it can be estimated that more than 20% of the species population will be lost by 2080.

e) Conservation:

Protected within the Maputo Special Elephant Reserve, Chririndzene Forest in Gaza, and Pomene National Reserve in Inhambane.

f) Rationale

Zanthoxylum delagoense is a near endemic to the MCE, and it is an endemic to Mozambique. It is found along the coastline from Maputo to Inhambane Provinces in southern Mozambique. This range overlaps with high human concentration. Therefore, large portions of the species habitat have experienced past and continue to experience ongoing degradation due to forestry resources exploitation, subsistence farming, and urbanization. With a generation length of 60 years, this taxon is suspected to have declined by 15% since 1943 and is expected to experience a further 20% decline by 2080. It therefore qualifies for the IUCN status of Vulnerable under criterion A4cd; B1ab(ii,iii,v)+2ab(ii,iii,v).

13 Emicocarpus fissifolius

a) Geographic range

The species has been recorded in the past from five localities in Maxaquene and Mavalane (EOO <200 km^2) within the actual Maputo city in Mozambique.

b) Rationale

Emicocarpus fissifolius was first collected in 1893 in what was known as Lourenço Marques, Delagoa Bay, present day Maputo city. In 1966, the last collection was made (Goyder unpublished ms) in Maputo city. Since then, it has not been possible to find the species within its very small historical known range of five localities. All these localities where the species was collected have been transformed for urban development. Searches in similar suitable remaining habitat within its known range took place twice during the growing season (January and October) in 2015. This taxon was not found and the habitat, which was checked during this study, was found to be highly degraded. It is suspected that no more suitable habitat remains for this species, and it has therefore been considered appropriate to list the species under the Extinct (EX) category.

APPENDIX C

Description of the land cover classes used on this study. The land cover data was sourced from GEOTERRA Image 2013-14.

Class	Class Name	Description
1.	Water	All areas of open water that can be either man-made or natural in origin. Based on the maximum extent of water identified in all seasonal image acquisition dates.
2.	Bare	Bare, non-vegetated areas *dominated* by loose soil, sand, rock or artificial surfaces. May include some very sparse scattered grass, low shrub and / or tree and bush cover. Can be either natural (i.e. beach) or man-made (i.e. mines or built-up areas).
3.	Low Vegetation & Grassland	Grass and low shrub *dominated* areas, typically with no or only scattered trees and bushes. Mainly natural or semi-natural vegetation communities in both urban and rural environments. May also include some subsistence cropping
4.	Tree / Bush Dominated Vegetation	Low tree and bush *dominated* areas, typically with lower canopy heights and more open canopy densities (i.e. open to scattered) than class 5 (below). Includes natural, semi-natural and planted vegetation communities in both urban and rural environments. Will also include young planted forest plantation stands.
5.	Tree Dominated Vegetation	Tall tree and bush *dominated* areas, typically with higher canopy heights and more compact canopy densities (i.e. open to closed) than class 4 (above). *Note: may include dense thicket, even if not composed of tall trees & bushes.* Includes natural, semi-natural and planted vegetation communities in both urban and rural environments. Will also include mature planted forest plantation stands and windbreaks.
6	Cultivated	Large-scale, commercially cultivated fields used for the production of both annual and permanent crops (i.e. maize, sugarcane, orchards etc.). The class includes both rain-fed and artificially irrigated fields. The class does not include small-scale subsistence and/or communal type cultivation.
7.	Sports, Golf and Parks	Managed grassland areas associated with golf courses, sports fields and urban parks.