CEPF Grant 63512: In From the Cold: Providing the Knowledge Base for Comprehensive Biodiversity Conservation in the Chimanimani Mountains, Mozambique

CHIMANIMANI MOUNTAINS:

BOTANY AND CONSERVATION

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Front cover: Mt Messurussero & *Brachystegia* woodland, N Chimanimani Mts (JT).

Frontispiece: Sunrise with Mt Messurussero (JT, top); view over upper Mufomodzi valley (JO, middle L); weathered quartzite by Mt Nhamadimo (JT, middle R); gold diggers, Mufomodzi tributary (JT, bottom L); *Disa fragrans* (JT, bottom R).

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SUMMARY

Straddling the Mozambique–Zimbabwe border at around 20°S, the Chimanimani Mountains have long been known as an area of high plant diversity and endemism. With almost three-quarters of the montane massif in Mozambique, the upland area covers around 530 km^2 and ranges in altitude from about 500 m in the south to the highest peak of Mt Binga at 2436 m. Most of the main plateau lies at around 1000 to 1800 m. The craggy appearance of the mountains results from the underlying geology of resistant Precambrian Umkondo quartzites, the weathering of which results in very nutrient-deficient soils. It is this that is believed to be the evolutionary driver for the exceptional levels of plant endemism found here. The mountains are protected on both sides of the border as a National Park or National Reserve, and together form they part of a Trans-Frontier Conservation Area (TFCA).

Despite being a protected area, the mountains were invaded in the 2004–2006 period by many thousands of illegal small-scale miners, who dug into stream beds looking for alluvial gold; perhaps a thousand still remain, nearly all on the Mozambique side. At the time, fears were expressed by conservationists over the possible impacts of these miners on the flora, vegetation and wildlife.

In order to evaluate any conservation impact, and to address the comparative lack of knowledge of plant distribution on the Mozambique side, the Royal Botanic Gardens, Kew in UK and the Micaia Foundation (an NGO in Mozambique), in conjunction with the National Herbarium in Maputo (Instituto de Investigação Agrária de Moçambique, IIAM) and the National Herbarium and Botanic Garden in Harare, received a grant in 2014 from the Critical Ecosystem Partnership Fund. This was to look at restricted-range and endemic species on the Mozambique side of the mountains in order to assess their distribution, the threats to them and their conservation status, and to provide appropriate conservation recommendations for the national authorities. Three field trips were carried out in different areas and in different seasons. This report describes and discusses the findings, and also provides some historical background to botany and plant collecting across the mountains.

A database of herbarium specimens of many range-restricted species known from the Chimanimani area was compiled, and a list of true endemics determined. Out of an estimated 920 taxa recorded from the mountains above 1200 m altitude, 78 taxa (species, subspecies and described varieties), or 8.5%, are believed to be endemic, including 9 taxa thought to be new to science. Nearly all these 78 endemics appear to be confined to quartzite sandstone substrates, with just two confined to schist grassland. The main habitats for the endemics are Ericoid scrub on quartzite outcrops or boulder slopes ("rock gardens"), quartzite rock faces and ledges, and some quartzite grasslands, with many of the species preferring relatively open, non-shaded habitats with some bare soil. Such habitats are widely dispersed across the whole massif and on both sides of the border.

IUCN Red List assessments of 66 endemic or near-endemic taxa were carried out, with 27 considered to be threatened (21 Vulnerable, 5 Endangered, 1 Critically Endangered) and 34 of the remainder being Least Concern, with 1 Near-threatened and 4 Data Deficient. However, a few of the threatened taxa are known only from lower altitudes in or adjacent to the threatened moist forests on the footslopes, or are near-endemics found also on nearby farms or Forest Land.

Unlike on the forested eastern footslopes where clearance for agriculture is common, followed by frequent fires and subsequent invasion by the introduced shrub *Vernonanthura*, habitat loss does not appear to be a major threat to the endemic flora of the Chimanimani Mountains. In general, populations of montane endemic species were found to be relatively intact and healthy in the core zone of the TFCA; they are less under threat than had at first been feared. This is primarily because rocky sandstone habitats are little used by the small-scale miners and mining activities are mostly confined to streams and stream margins, habitats that are not significant for the range-restricted species. However, gold mining activities are having very deleterious effects on aquatic ecosystems, particularly on flow regimes and probably on populations of aquatic invertebrates and vertebrates. There also appears to have been a significant reduction in the populations of larger mammals on the grasslands, populations for which the mountains were known in the past.

Owing to the large numbers of people now living or passing through the mountains, it is assumed there has been an increase in the incidence of fire, but the impacts of fire and fire frequency are still not clear. It is probable that Ericoid scrub and the margins of small patches of moist Afromontane forest are being affected, but to what extent is not known.

Ten recommendations are given concerning management actions and possible further research. The major management issue for the core zone of the mountains is to control the numbers of small-scale miners active there, while on the lower slopes and in the buffer zone the main issues are to control the increase in forest clearing for agriculture, wildfires and the spread of the invasive *Vernonanthura*.

1. INTRODUCTION

The Chimanimani Mountains, lying on the border between Zimbabwe and Mozambique at around 19°50' South, have been recognised as an important area for plant biodiversity for at least 50 years (Wild 1964, van Wyk & Smith 2001, Mapaura 2002). In addition, the mountains have been recognised as one of the main Key Biodiversity Areas (KBAs) in the Eastern Afromontane Hotspot (Eastern Afromontane Ecosystem Profile, CEPF 2012: 174). However, although the smaller Zimbabwe portion of this montane massif has been relatively well studied, much less is known about the Mozambique portion. This disparity has become more relevant over the last 15 years as there has been a significant influx of illegal small-scale gold miners (*gariemperos*) and significant environmental damage, particularly on the Mozambique side. It was not known what impact this might be having on plant diversity, in particular on the more than 75 endemic species.

With this conservation issue in mind, an application was made to the Critical Ecosystem Partnership Fund (CEPF) by the Royal Botanic Gardens, Kew (Kew) and the Mozambican NGO the Micaia Foundation (Micaia) for a grant to both address the comparative imbalance in botanical knowledge across the border and to look at the impacts on plants of small-scale artisanal mining. Other partners in this project included the National Herbarium at the Instituto de Investigação Agrária de Moçambique (IIAM) in Maputo and the National Herbarium (SRGH) in Harare.

After discussions, the agreed grant was divided into two components, one dealing with botanical and conservation field studies in the montane parts in Mozambique (carried out primarily by Kew) and an awareness-raising and management-orientated component to be carried out by Micaia. This report covers just the first component (for the Micaia-led component see www.cepf.net/SiteCollectionDocuments/eastern_afromontane/FinalReport-MICAIA-62603.pdf), although activities in most cases were carried out jointly. The stated activities were:

a) Produce a clear and detailed assessment of the conservation threats to the range-restricted or threatened species and their habitats, with particular reference to the threats arising from artisanal mining.

b) Produce a series of preliminary conservation assessments for the recorded endemic/near-endemic or threatened species for submission to the IUCN Red List Authority, further justifying the importance of the KBA [Key Biodiversity Area].

c) Produce a set of evidence-based recommendations for presentation to the Mozambique and TFCA [Trans-Frontier Conservation Area] authorities on appropriate conservation actions that could be taken.

d) Collect some hundreds of fully labelled and georeferenced plant specimens collected for the Maputo, Kew and Harare herbaria, which will also provide a basis for a preliminary listing of species and locations for future targeted seed collection under a joint Micaia/community/Kew Millennium Seed Bank project aimed at ex situ propagation and conservation.

e) Produce a comprehensive report documenting all findings, which will be presented at a joint workshop held with Birdlife Zimbabwe to assist in dissemination of findings and conclusions.

f) As a result of training from RGB Kew, staff members from IIAM, Harare Herbarium and Micaia will be more capable of conducting botanical surveys.

Included among the outputs of the botanical component were (a) increased and better-documented knowledge of the endemic and range-restricted plant species found in the Chimanimani Mountains, (b) possible new species identified, (c) IUCN Red List assessments carried out for the majority of these species of interest, (d) a clearer identification and justification for its status as an Important Plant Area (IPA) and Key Biodiversity Area (KBA), and (e) an assessment of the conservation threats posed by artisanal mining to those species.

After preliminary documentation work and selection of the species of interest, herbarium specimens of these species at both the Kew Herbarium (K) and National Herbarium in Harare (SRGH) were databased and georeferenced where possible. Owing to historical collecting patterns, hardly any specimens of these species were thought to be in the National Herbarium at IIAM (LMA) or the University Herbarium (LMU) in Maputo. Three fieldtrips were undertaken by staff from Kew, Micaia, the Maputo Herbarium, the Harare Herbarium and other botanists (Meise, Belgium and the Natural History Museum, London) in April 2014, September 2014 and April/May 2016, resulting in over 1000 specimens being collected and identified. During fieldwork a number of artisanal mining areas where extraction of gold from streams and rivers was taking place were visited to determine impacts.

This report covers these activities and presents the main findings and recommendations, along with a background to the area, its botany, vegetation and ecology.

Along the base of Mt Binga, N Chimanimani [BW]

2. DESCRIPTION OF THE AREA

The Chimanimani Mountains – the name is said to be derived from a Ndau word T'shimanimani meaning a gorge or gap (Dutton & Dutton 1975) – form part of the Mozambique–Zimbabwe border between 19°36' and 20°04' South. They extend for around 50 km north to south and are about 20 km wide at their widest (Figures 2.1, 2.2, 2.3). Of the rocky montane area – roughly defined as that area above 500–700 m altitude in the south and east and 1000–1200 m in the west and north – the largest portion, perhaps three-quarters, lies in Mozambique.

The mountains characteristically comprise quartzite or white sandstone crags, interspersed with more gentle grasslands, forming a plateau that slopes eastwards into Mozambique. An accurate figure for the total extent of the massif is not available, but from polygons drawn using Google Earth Pro an estimate of the area on both sides of the border above where the land starts to rise steeply from the surrounding pediment and hills was made (Timberlake, unpublished). This was around 530 km^2, of which 380 km^2 is underlain by quartzite and 150 km^2 comprises schist grassland.

The principal features of the Chimanimani Mountains, the main montane massif covering just the Core Zone of the Trans-Frontier Conservation Area (TFCA) – the Chimanimani National Park in Zimbabwe and the Reserva Nacional de Chimanimani in Mozambique – are given below. Other upland areas included within the broader TFCA (i.e. the Buffer Zone) – such as Rotanda and Tsetserra in Mozambique, the Mussapa Gap, Forest Land, Musapa Mountain, the Himalayas and Banti Forest in Zimbabwe – are not specifically covered here. Details on vegetation are given later in Section 5.2 and previous studies are summarised in Section 4.

2.1 Administration

Administratively, in Zimbabwe the Chimanimani Mountains fall entirely in Chimanimani District, with the District Administration based in the small farming and tourism town of Chimanimani (formerly Melsetter) around 20 km away to the west at an altitude of 1200 m. The entire montane area is protected as the Chimanimani National Park. Apart from some former commercial farms lying west of the Haroni River but adjacent to the National Park, there are a number of Forest Areas (Martin I & II, Lionhills, Chisengu, Tarka and Glencoe Forest Lands) administered by the parastatal Zimbabwe Forestry Commission. These are used primarily for commercial plantation of *Pinus* species, although they do contain some pockets of natural vegetation. At the far south of the mountains lies the Rusitu Valley (the Rusitu River becomes the Rio Lucite when it enters Mozambique) at an altitude of 320 m in which there are two Botanic Reserves – Rusitu and Haroni – protecting lowland forest, as well as the lowland Mukurupini forest at the southern end of the National Park.

The Mozambique portion of the mountains lies in Sussundenga District of Manica Province, with the District Administration at the small town of Sussundenga some 40 km to the north-east. In the lowlands (150–350 m altitude), on the footslopes and pediplain to the east of the mountains, numerous communities engaging in subsistence agriculture are found, such as at Maronga, Zomba and Mahate. People have been living in these lowland areas for many years, although probably at a lower population density than at present (Hughes 2006, Bannermann 2010). Many people moved out during the civil war from 1978 to 1992, but have since moved back. Expansion of clearance for agriculture has been especially noticeable over the last 10 years. Natural resource management, conservation and livelihood issues arising from this expansion are being addressed, amongst others, by Micaia and RBG Kew through a Darwin Initiative project (Balancing Conservation and Livelihoods in the Chimanimani Forest Belt, Mozambique; see Timberlake *et al.* 2016).

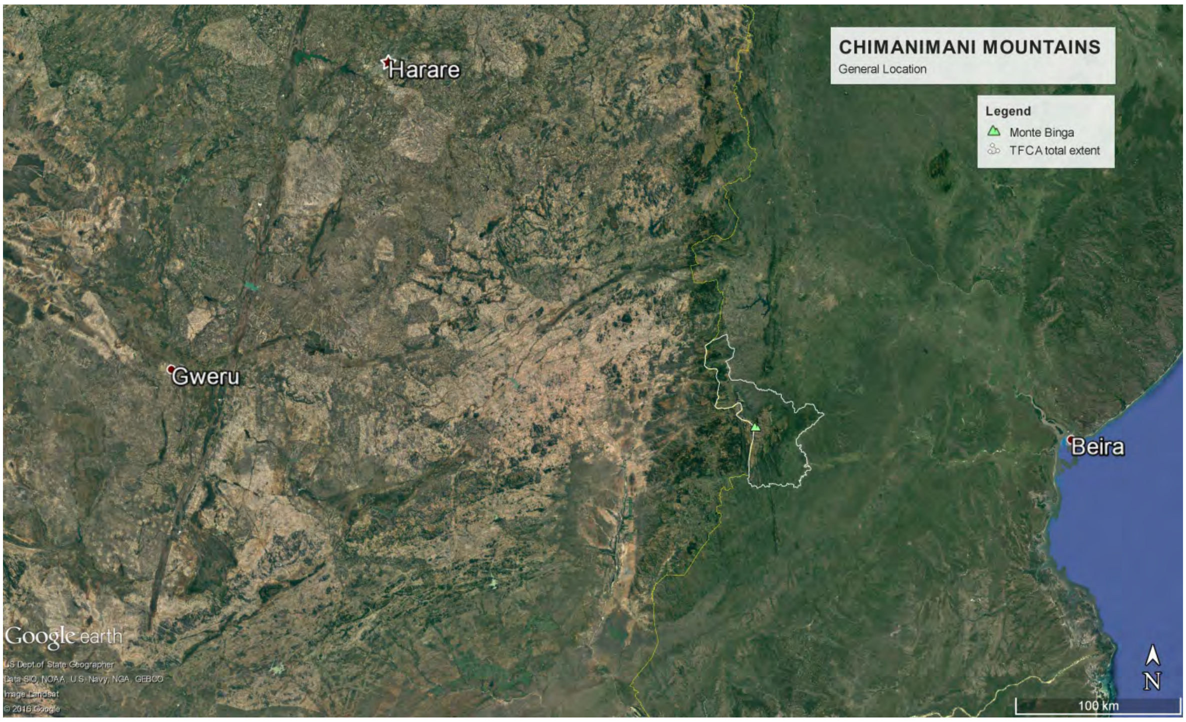


Figure 2.1. Location of the Chimanimani Mountains on the Mozambique–Zimbabwe border.

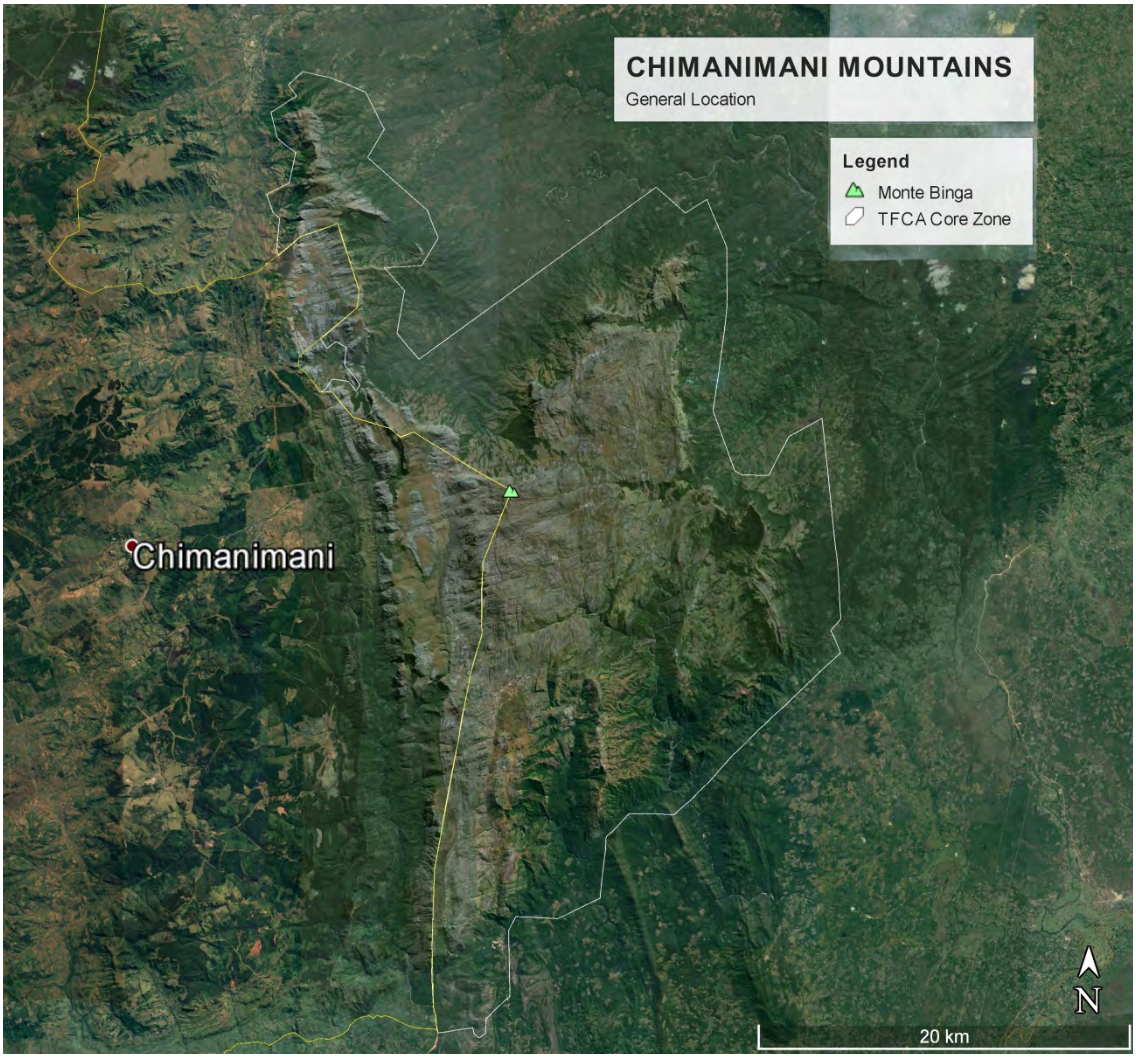


Figure 2.2. Detailed Google Earth image of the Chimanimani massif. The quartzite rock appears paler.

The Chimanimani Transfrontier Conservation Area, which should be a jointly-managed conservation area straddling the international border, includes a core non-use zone and a buffer zone in which habitation and natural resource use is allowed. This is discussed later (Section 3.4).

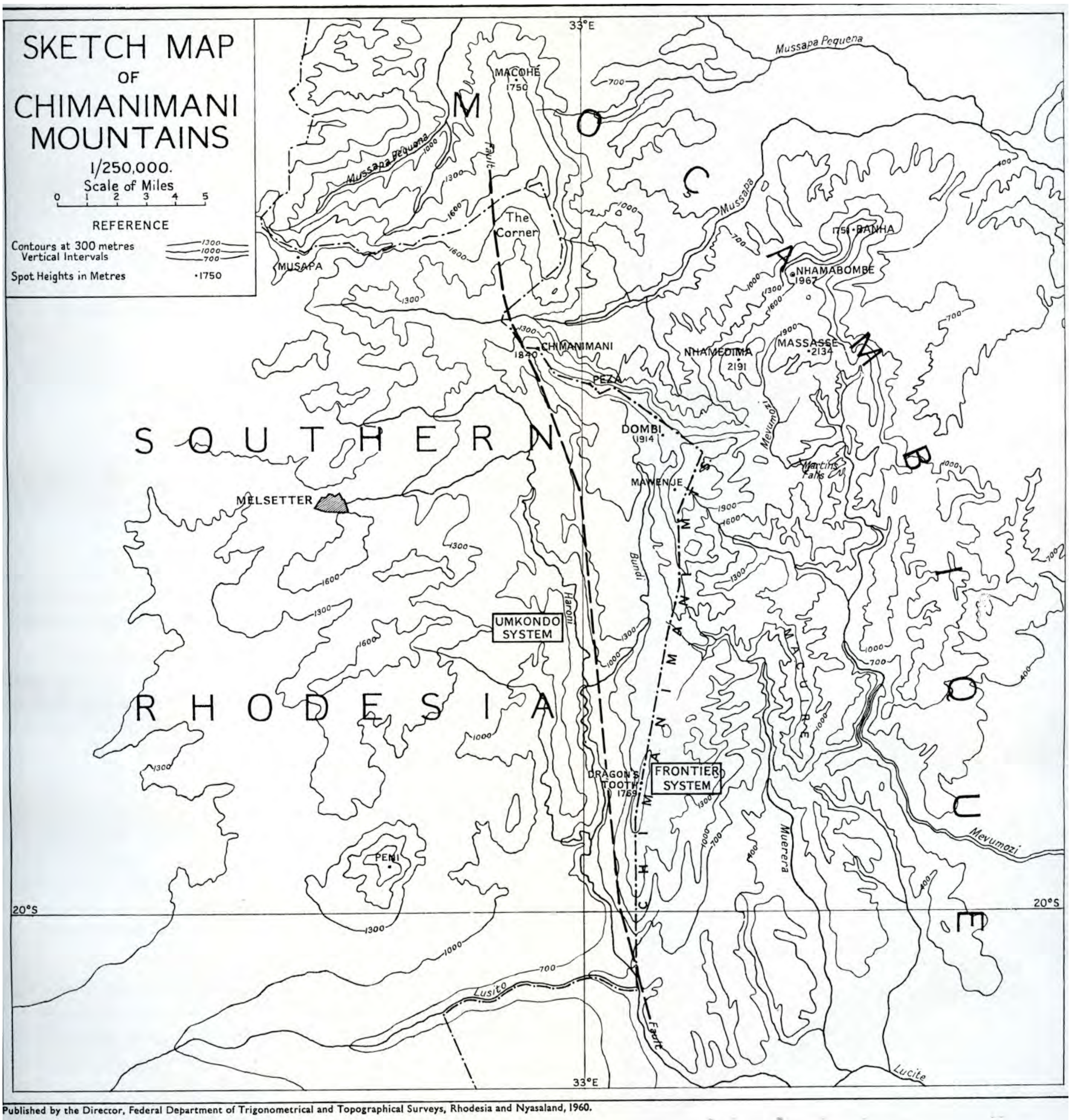
2.2 Physical Features and Geomorphology

The Chimanimani Mountains are a massif rising, often very steeply, from the Central African plateau. There are three north–south ridges – the first in Zimbabwe in the west is fault-determined with the Haroni River running south along its western side, the second forms a series of high points (e.g. Mts Messurussero, Dombe, Mawenje, BB71a) along the international border, while the third is much shorter and lies at the far eastern edge of the massif above Zomba. In between, the massif is dissected, sometimes very deeply, by north–south-flowing rivers such as the Bundi in Zimbabwe, and the Rio Murera (or Morera) and Rio Mufomodzi (or Mevomodzi) in the Mozambique part.

The majority of the massif lies at an altitude of between 1000 and 1800 m (1500–1800 m on the Zimbabwe side, Phipps & Goodier 1962), with the highest point being Mt Binga at 2436 m altitude on the international border. Other significant peaks are Mt Peza (2152 m), Mt Dombe (2188 m) and Mawenje or Turret Towers (2362 m) in Zimbabwe and Mt Nhamadimo (2144 m) in Mozambique.

On the Zimbabwe side, most of the drainage is into the Bundi River, which in turn flows into the Haroni. In the foothills at the southern end of the mountains, the by-now lowland Haroni joins the larger east-flowing Rusitu River, which becomes the Rio Lucite on crossing the border. The smaller Mukurupini (or Makurupini) River, flowing south off the very southern end of the massif, forms part of the international border before it joins the Haroni (although this is disputed by Capela (2006), who suggests the border lies more to the west along the Haroni). Much of the centre and north of the Mozambique part of the massif is drained by the Rio Mufomodzi, which in its lower reaches flows through the lowland forest and agricultural areas of Zomba to join the main south-flowing Rio Mussapa east of the main massif. The Mussapa eventually flows into the Rio Lucite and in turn into the Rio Buzi, which enters the Indian Ocean near Beira. The Mussapa actually rises north of Chimanimani town in Zimbabwe then crosses eastwards through the quartzite ridge at Chikukwa in the Mussapa Gap, after which it is called Rio Mussapa Grande. From the confluence with the Mussapa Pequeno coming from the north, it becomes the Rio Mussapa (although on some maps this is surprisingly still called the Mussapa Pequeno). The northern footslopes of the massif in Mozambique drain into the Rio Nyamadzi in the centre-north, which in turn flows into the Mussapa Grande, while the east-north-east slopes drain into the Rio Mucutucu and then to the Mussapa. There seems to be a certain amount of confusion with river names in this area, with different "official" maps having different names.

The largest and most extensive gorges are along the middle reaches of the Rio Mufomodzi and Rio Muerera in the south-eastern part of the massif, and also along the middle and lower reaches of the Haroni River in Zimbabwe. These deep gorges have effectively blocked east-west access across the area. Perhaps the three best known waterfalls are Mufomodzi or Martins' Falls (19°46'51"S, 33°07'05"E, 1500 m) and Gossamer Falls (19°53'10"S, 33°08'41"E, 490 m) on the upper and middle Mufomodzi in Mozambique, Mukurupini Falls (19°59'59"S, 33°01'55"E, 870 m) on the upper Mukurupini in the far south, and Ragon Falls (19°52'02"S, 33°01'37"E, 1226 m) where the Bundi falls off the massif towards the Haroni in Zimbabwe.



Published by the Director, Federal Department of Trigonometrical and Topographical Surveys, Rhodesia and Nyasaland, 1960.

Figure 2.3. Map of the Chimanimani Mountains (from Goodier & Phipps 1961, Kirkia).

The least rugged part of the massif – and thus the area that has been best explored botanically – is the central northern part, extending across the border from the Bundi Valley and Southern Lakes area of Zimbabwe across to Mt Nhamadimo (or Nhamudima), Martin's Falls and the Ma-Esese areas in Mozambique, as well as the readily-accessible Corner in Zimbabwe and the Mussapa Gap (see Annex 2).

Erosion Surfaces

The landforms here are undoubtedly ancient. Some have suggested that the upland and montane areas along the Zimbabwe–Mozambique border, and further north into Malawi, represent the ancient vestiges (Permo-Triassic period c.250 mya) of a Trans-Gondwana Mountain Belt (Key, Cotterill & Moore 2015). However, the first reference to ancient geomorphology was by King (1962), who suggested that the highest part of the Nyanga and Chimanimani mountains forms part of Gondwanaland (Jurassic) or post-Gondwanaland (Cretaceous) land surface.

Based on this, Lister (1987), in her study of the erosion surfaces of Zimbabwe, suggested that the peaks of the northern Chimanimani above 2200 m (e.g. Dombe, Binga, Mawenje) represent a residual Gondwanaland erosion surface dating from 186–146 million years ago (mya) (mid to end Jurassic), whereas the saddles in between and much of the remainder of the northern Chimanimani above 1970 m represent the post-Gondwanaland erosion surface (early Cretaceous, 145–100 mya). Below about 1750 m is the African erosion surface (mid-Cretaceous to end of Oligocene, 100–23 mya), while valleys such as the lower Bundi at around 1450 m represent the post-African surface (Miocene, 23–5 mya), which also covers much of the central parts of Zimbabwe. Wild (1964, quoting G. Bond pers. comm.) gives a somewhat shorter period and states that it is believed the quartzites would have been exposed more-or-less as they are today since at least the beginning of the Tertiary (around 65 mya).


Figure 2.4. Chimanimani vista with *Dissotis pulchra* [BW]


Figure 2.5. View over upper Mufomodzi valley [JT]

Caves

An interesting aspect of the high Chimanimani Mountains is the presence of deep caves, very different in formation and structure than the better-known shallow rock overhangs that people have commonly used for shelter. After first being noted by someone from Zimbabwe's Outward Bound Centre in the area behind Mawenje (Turret Towers), almost on the international border, the first exploration was by a group of South African cavers and Zimbabwe Mountain Club members in 1990 and 1991 (Howell 1990, Trueluck n.d.). This was followed by a larger trip in 1992 by cavers from the South African Speleological Association (Le Roux *et al.* 1993), and then by a larger and lengthier expedition by cavers from South Africa and Zimbabwe in 1993 (Koliasnikoff 1994, Trueluck n.d.). Fourteen caves were recorded, eight were explored and six were surveyed, one of which is just over the border in Mozambique (Mozpot). The deepest shaft surveyed (Mawenge Mwena) is 305 m deep.

All the caves have been developed by water erosion of the Frontier quartzites and seem to be linked to doline-like features (Trueluck 1994a). As far as is known, these caves have not been explored since, probably as they require specialist equipment and skills.

As regards biodiversity, no troglomorphic invertebrates were found inside them (Trueluck 1994b), just animals that had been washed in. A few insectivorous bats were seen, but mostly in the upper reaches and in crevices.

2.3 Geology & Soils

It is geology that determines not only the presence of so many endemic plant species, but also their distribution across the mountains (Phipps & Goodier 1962). The great majority of the endemics are restricted to soils derived from the very nutrient-poor quartzitic sandstones.

The rocks of the Chimanimani area are primarily of the Frontier Series of the Umkondo Group, sediments over 1785 million years old dating from the later Precambrian period and which lie on the older Archaean Basement Complex (Watson 1969). These ancient sediments were deposited in a basin lying mainly in Mozambique, and have since been extensively overfolded and piled up against younger rocks, possibly by tectonic events 400–650 million years ago (Stagman 1978). They have also undergone low-grade metamorphosis.

The Chimanimani massif itself comprises four groups of sediments originally laid down in shallow water environments – in decreasing order of age, the Lower Quartzites, the Lower Chlorite Schists, the Upper Quartzites, and the Upper Chlorite Schists. These have been described in detail for the Zimbabwe portion by both Watson (1969) and Stagman (1978). The northern half of the Chimanimani comprises Lower and Upper Quartzites, with sandy and often iron-rich and micaceous Lower Chlorite Schists in between. Rocks are folded into a N–S synclinal structure, complicated by over-folding (klippen), multiple thrusting and facies changes. The highest ridge along the Mozambique–Zimbabwe border (Mt Dombe, Mt Binga and Mawenje to south of The Saddle) consists of Lower Quartzites, whereas the Upper Quartzites predominate south of this. Although it is not explicit in Watson (1969), one can assume that the southern parts of the Chimanimani massif, and possibly some of the eastern parts in Mozambique, consist of Upper Quartzites. According to the Mozambique geological map (ING 1987), much of the Chimanimani massif comprises quartzites (CG^{FQ}), with significant extents of mica-schists with aluminium and quartzite (CG^{F}) to the east; these overlie older Precambrian quartzitic gneiss (CG^{N}) on the lower slopes.

The quartzites, or metamorphosed sandstones, are generally fine to medium-grained (Watson 1969), granular (occasionally termed "sugary"), massive and whitish, appearing at times like a medium-textured sandstone. There is a well-developed system of joints and fractures that generate distinctive weathering features. On some vertical faces there is an unusual weathering phenomenon with the formation of honeycomb-like structures (tafoni, Lister 1987), sometimes passing right through a boulder. Quartzite landscapes are often rugged and full of boulders, while the schists on the other hand are sandy, chloritic and micaceous meta-sediments. Landforms derived from the latter generally show undulating grassy slopes with reddish-brown soils, for example the gentler slopes of Mt Peza north of Mt Binga and much of the Bundi Valley in Zimbabwe.

Soils

Soils found on the Chimanimani massif are primarily determined by the underlying geology, a link that is also true for much of the surrounding lowlands, although depositional soils become significant on the eastern footslopes. As with so much of the geology and ecology, they are better documented from the Zimbabwe side.

As mentioned above, the main crags of the Chimanimani Mountains consist of highly-folded quartzites and metamorphosed sandstones of the Frontier Series interspersed with more-readily eroding schists. The latter give rise to more rounded, less rocky, grassy hills, whereas the quartzites give rise to heavily-weathered nutrient-poor soils.

Phipps & Goodier (1962) describe four main soil types in the montane areas: (i) red soils derived from schist, (ii) white sandy soils derived from quartzite, (iii) alluvial soils fringing larger streams and small rivers, and (iv) forest soils which are humus-rich and underlie the moist forest. These are briefly discussed below. Detailed analyses of some soils are given in Phipps & Goodier (1962, Table 4).

Soils derived from schists (not from the Umkondo sediments as stated in Wild 1964) are orange-red in colour, and range from shallow and rocky on steeper slopes to more mature soils around 45–60 cm deep on gently undulating grassland slopes. They have a higher water-retaining capacity than quartzite soils owing to their 20% clay content, but are low in exchangeable bases (less than 1 m.e.%), presumably a result of leaching over a long period (Phipps & Goodier 1962). However, compared to quartzite soils they are significantly higher in available phosphorous (50 ppm).

White quartzite soils, on the other hand, have less than 1% clay hence a low water-retention capacity, and less than 1.5 m.e. % exchangeable bases (Phipps & Goodier 1962). They range in depth from almost zero (outcrops of rock, sometimes with a lithophytic flora or just small pockets of vegetation) to soils up to 30 cm deep in flattish areas. However, the somewhat deeper soils here are very sandy with little humus, except where a sort of bog vegetation occurs. Apart from colour and texture, their main differentiating characteristic is that they are also very low in available phosphorous (less than 5 ppm), which is thought to be a significant factor in promoting sclerophylly (i.e. with evergreen leathery leaves; Wild 1964).

Alluvial soils flanking larger watercourses can be derived from either quartzite or schist, but tend to have similar properties to quartzite soil. Very acidic bog vegetation is also found.

Forest soils are derived from either quartzite or schist and their properties are a result of the vegetation cover, with a significant well-drained humus layer being formed. Forests are nearly always found on slopes or among rock outcrops.

Coupled with changes in altitude, it is this distinct difference in soil properties that gives rise to the range of vegetation types found across the mountains.

2.4 Climate

Rising out of the low Mozambique plain the Chimanimani massif intercepts moisture-laden air coming from the Indian Ocean, resulting in high levels of orographic precipitation. Being in the rain shadow from the prevailing south-easterly air flows the Zimbabwe side is drier, but there do not seem to be any specific data on this.

The main summer rainy season is from November to late March or April, but on the high mountains rain can occur throughout the year; the dry season is not as marked here as it is on the central plateau below. No accurate figures exist for the mountain and escarpments, but by extrapolating from similar areas in Zimbabwe rainfall is estimated to be between 1500 and 2000 mm/year. Phipps & Goodier (1962) state that further north in Zimbabwe, Mt Nyangani (Inyangani B) receives 2997.2 mm/year; the figure for the higher east-facing parts of Mt Binga and Mawenje may be similar, indicating that the high mountain peaks can receive almost 3 metres of rainfall each year. For Inyangani B the wettest month was January with 639.3 mm, while the driest was July with 37.8 mm.

The nearest available rainfall figures in Zimbabwe (Agritex/FAO 1989; Table 2.1) are for Chimanimani District Administration (Chimanimani town in Zimbabwe, 1520 m) and for Chisengu Forest Area (1340 m), which lies a bit further south but still within the rain shadow of the mountains. The figures are 1074 and 1406 mm/year, respectively. However, Phipps & Goodier (1962) give an average figure for Martin Forest on the western (rain shadow) side of the Chimanimani as 1072.3 mm/year (Table 2.1).

There are no rainfall data available for the Mozambique portion of the Chimanimani Mountains.

A major feature of the mountains is the frequency of mist ('guti') and overcast days during the dry season (Phipps & Goodier 1962), which effectively decreases the length and stress of the dry season. In the wet season a "mist belt" is often present at 1500 m and above.

Table 2.1. Rainfall figures for Chimanimani area, Zimbabwe (from Agritex/FAO 1989 [1]; Phipps & Goodier 1962 [2]).

	Chimanimani[1]	Chisengu[1]	Chipinge[2]	Martin Forest[2]
Average rainfall (mm/yr)	1073.7	1406.1	1060.8	1072.3
wettest month (mm)	215.8 (Dec)	246.2 (Dec)	212.8 (Jan)	234.0 (Jan)
driest month (mm)	16.3 (July)	37.0 (July)	18.3 (Sept)	10.8 (July)
wettest year (mm/yr)	1704.6 (1954/5)	1766.6 (1987/8)		
driest year (mm/yr)	554.3 (1963/4)	960.3 (1986/7)		
period	32 years (1952-1984)	26 years (1955-1972, 1976-1987)		

As regards temperature, the climate is generally considered humid tropical to temperate (Ghiurghi, Dondeyne & Bannermann 2010, Annex 2) with average temperatures across the eastern Chimanimani area of 23–25°C in January and 17–19°C in July. Mean average temperature varies from 22°C in the south-eastern lowlands to less than 18°C in the high mountains. Frost is frequent on the plateau above 1500 m, but absent from the low valleys. Phipps & Goodier (1962) give tabulated mean maximum and minimum temperature figures for a number of localities in Eastern Zimbabwe, showing that frost is not uncommon from May to August.

Waterfall (Tucker's Falls) with Afromontane forest at base, N Chimanimani [JT]

3. HISTORICAL BACKGROUND

3.1 Prehistory & Archaeology

The archaeological record for the Chimanimani area is poor compared to many other places in the region. There are records from caves up in the mountains (1000–1700 m) of what are probably Late Stone Age sites with Bushman (Khoisan or San hunter-gatherers) rock paintings. On the Zimbabwe side, in the northern extension called The Corner, at least six rock art sites were documented (at c.1400 m altitude) during a Rhodesian Schools expedition (Hughes & Gunns 1973), and a local informant (Chief Nyahedze) also mentioned rock paintings in this broad area. Dutton & Dutton (1975) mention cave paintings, but it is not clear if they were found on the Mozambique side. Rob Burrett (pers. comm., June 2014), a Zimbabwean archaeologist, mentions rock art at Ragon Falls, St Georges Cave, Red Cave and at a small site towards the Mussapa Gap, most of these being in Zimbabwe, while Doug van de Ruit (pers. comm., November 2014) mentions rock paintings and an old iron smelting facility, but without locality. Garlake (1995), in his study of the prehistoric art of Zimbabwe, does not mention any sites in the Chimanimani area, but this may be because any such paintings there weathered away more rapidly compared to those on the less permeable granite or syenite of the other mountains, such as the Matopos and Nyanga. Bannermann (2010), in his detailed account of the history of the Mozambique side of the Chimanimani area, mentions "many of these [rock art] sites in the project area" including on the high Chimanimani plateau, Chikukwa Ferreira (The Corner) and (outside our study area) on rock outcrops between Mavita and Rotanda.

It is probable that the Bushman and subsequent peoples generally did not live on the high mountain plateau but only in lower, more sheltered areas, perhaps just going into the mountains for hunting. There is also the issue that in recent years any rock art may well have been destroyed or severely damaged by fires and the use of caves for shelter by gold-panners.

There seems to be rather little in the way of more recent archaeological evidence from the Chimanimani massif, although more has been found on the footslopes and at lower altitudes. This is surprising given the number of archaeological finds on similar upland areas in Nyanga (Soper 2002) and Mt Mulanje and the Nyika plateau in Malawi (Rangeley 1960, McCracken 2006), ranging from iron smelting to hut sites to field boundaries. In his extensive study of agriculture and archaeology in the Nyanga area, Soper (2002) does not mention any similar historic activity in the Chimanimani area, apart from a cryptic reference by Beach (in Soper, p.202) to "...reported terraces and fortifications from the eastern [Mozambique] side of the Chimanimani range..." based on comments in Octávio Roza de Oliviera (1973).

What is not clear is if this lack of archaeological record and evidence is due to an absolute lack or because little effort has gone into looking for remains up on the massif. Or perhaps the terrain is just not conducive to preserving or locating archaeological sites. Given the harsh climate (high rainfall and low temperatures) and the great paucity of soil nutrients compared to the dolerite and granite soils of Nyanga and Matopos, the area perhaps had too low a carrying capacity for human settlement. Agriculture of any type is unlikely to have been feasible on quartzite soils above 1500 m and the carrying capacity for any grazing animals, domestic or wild, would also be very low.

3.2 Colonial & Recent History

As might be expected, the more recent and colonial history of the Chimanimani area is much better documented from the Zimbabwe side than from the Mozambican, although Bannermann (2010) gives a detailed and comprehensive account for Mozambique. Much of this is based on Appendix 3 of the late Richard Bell's management plan, a document that was almost lost (see Ghiurghi *et al.* 2010a: 7). Bannermann's account covers the community histories on that side from the Early Iron Age (Chifumbazi), through the trading era of the Mutapa and Zimbabwe states around 1300–1500 to the early colonial Portuguese traders, the Portuguese attempts to supress Chief Ngungunhane (or Ngungunyana) and the establishment of the colonial trading companies. It ends up discussing the impact on communities of both the liberation struggle that ended with a Frelimo government in 1975 and the subsequent civil war with Renamo. Some relevant details from his account are given below. The communities discussed by Bannermann are mostly those living along the rivers and in the forests on the low-altitude areas (150–350 m altitude); the mountains themselves seem to have played little role in this history and have had minimal economic importance.

A detailed account of the resource politics around the Moribane Forest Reserve on the Chimanimani foothills is given in Schafer & Bell (2002), while Hughes (2006) covers the political and resource history on both sides of the border, with particular reference to communities living at the southern end of the mountains in Maronga.

According to Bannermann's (2010) account (much of what is written below is based on this), there was a significant trade in gold from the hinterland to the coast from around 500 AD onwards, which later focused on the Great Zimbabwe area of the Monomatapa Kingdom. Gold was also mined in these early days in areas to the north of Chimanimani, such as Bandire east of Rotanda and at Penhalonga just north of present-day Mutare in Zimbabwe. Trade routes, probably through the Mussapa Gap and further south along the Rusitu/Lucite valley, went to Sofala on the Buzi estuary, which was the chief seaport for the Monomatapa Kingdom.

A more modern history of the Mozambique side probably starts with the establishment of an administrative zone (Circunscrição de Moribane) based at Mavita in 1894. This was initially administered by Sr. Campos Santos, and later by José Luis Ferreira, after whom the Moribane centre was named around 1900. It was Ferreira who, in 1899–1907, built a road from Macequece (now Manica town) to Mavita and on to Melsetter (now Chimanimani town in Zimbabwe), probably through the Mussapa Gap, and it was this road that probably did most to open up the area economically.

Much of the interest in the area seems to have focussed on the possibilities of wild rubber (sap from lianas of *Landolphia*) and timber in the forests along the Chimanimani foothills. The Companhia de Moçambique encouraged the planting of rubber vines, and the Moribane Company established plantations along the banks of the Mussapa and Mutucutu rivers in Zomba. Forced labour with very low wages was often imposed. A Frenchman, Paul Bindé, also established a *Landolphia* plantation near the Rio Lucite in Maronga in the far south around 1907. In addition, small quantities of bananas, papaya and citrus were planted.

However, in the 1940s the Companhia de Moçambique, which was effectively controlling this part of Mozambique, collapsed and its administrative functions were taken over by the Portuguese state. Soon after, administrative posts were established in Dombe and Mavita, and then, in the 1940s to 1950s, forestry concessions and sawmills were established in the Moribane–Mavita area to exploit the lowland moist forest and dense woodland. The Forest reserves of Maronga, Zomba and Moribane were gazetted in July 1953 (see Gomes e Sousa 1968, Timberlake *et al.* 2016), but it is not clear if these reserves were protect places from exploitation or just to control concessions and extraction. Later, in the 1960s, cotton and wheat production was encouraged in the lowland areas, and a Sr. Carvalho established a large farm on Tsetserra, one of the northern, non-quartzite plateaux.

During the Zimbabwe Independence struggle, the Rhodesian forces not only mined some of the montane passes but also attempted to disrupt communications in border areas to try and stop incursions by ZANU fighters. For example, in 1976 to 1980 the Rhodesians destroyed large bridges across the Lucite and Mussapa rivers, which have only recently been rebuilt. At around the same time, the newly-independent Frelimo government established communal villages (aldeias communais) at Rotanda and Dombe, and expected most people to live there rather than scattered throughout the agricultural areas. This caused dislocation of rural populations, which in turn effectively assisted destabilization by Renamo. Economic activity in the area stagnated and this has had an effect on subsequent land use in the lowland areas. The civil war between Renamo and Frelimo ended in 1992 with a peace accord, but even since then there have been some disturbances.

On the Zimbabwe side, modern colonial history started with treks in 1892 from what was the Afrikaner (Boer) Orange Free State in South Africa. The two Moodie treks, led by brothers Dunbar and Thomas Moodie, were encouraged by Leander Star Jameson on behalf of Cecil Rhodes' British South Africa Company to move into the territory called Gazaland to the west and south of the Chimanimani Mountains. This was to act as a bulwark against possible Portuguese expansion and to ensure the Company's dominance in the area. At this time the international border was not clear and each side, the Portuguese authorities and the British South Africa Company, was each trying to claim more territory – "Ultimately, they [the treks] kept Portugal south of the Rusitu River and east of the Chimanimani mountains" (Hughes 2001). Active possession through settlement and farming was considered to be "nine-tenths of the law". The Portuguese authorities were also struggling at this time with insurrection led by great Shangaan chief Ngungunyana (Mullin 1994).

The treks (there were nine in total; Hughes 2006) ended up in the area around the moderately fertile and well-watered headwaters of the Haroni and Nyahode rivers which they called Melsetter. Each settler could stake out land under 'Pioneer Title' granted by the British South Africa Company, and use the local native population living there for labour. Many farms were established at this time on higher ground, ranging from Cashel in the north southwards to what is now Chipinge and west to Gwendingwe. However, there seem to be few references (although see below) to land being claimed in the Chimanimani Mountains themselves, probably as it was recognised to be of very low agricultural potential. The history and subsequent development of the Melsetter–Chipinga area and its agriculture is given in detail by Sinclair (1971).

It is not known if there was any Portuguese settlement in the western area before this. However, one interesting but not well-documented find was of the ruins of a small square building in Mutema Communal Land some 40 km southwest of present-day Chimanimani, where a small-bore cannon, possibly made in Scotland around 1668, was found (Martin Sanderson, pers. comm., May 2016). This may have been a small fort on the gold-trading route from the Great Zimbabwe area to Sofala on the Buzi estuary, and indicates the importance of early trade to the coast through the Chimanimani area.

The international boundary itself, following the watershed between east- and west-flowing rivers on the second, western ridge (except in the Mussapa Gap area; Bannermann 2010), was only settled by the Anglo-Portuguese Boundary Delimitation Commission in the late 1890s. The concrete beacons were put in place by R.S.T. Fairbridge and A.E. Wayland in the 1920s (Sinclair 1971). However, this artificially split the Ndau-speaking communities which lived on both sides of this new border, but probably did not act as a barrier to their regular movement.

Hughes (2001) describes how the settlers in Melsetter used the native African inhabitants as somewhat involuntary labour. This was not considered a good state of affairs by some of the colonial authorities, and in 1896 the Native Commissioner J.D. Hulley, followed by his successor L.C. Meredith, created Native Reserves in lower-altitude areas such as Ngorima in the Rusitu valley at the southern end of the Chimanimanis. This allowed Africans to avoid what was effectively forced labour and maintain a certain independence. The reserves, which remain until today in terms of their boundaries, have had an effect on subsequent agricultural development in the Chimanimani area. Their creation has also had a significant effect on the conservation of the lowland forests at the southern end of the mountains in Zimbabwe, and the later creation of Botanic Reserves within them is still contentious (Hughes 2001, 2006).

On the Mozambique side of the mountains land was not "alienated" to colonial settlement (Hughes 2006), and because land was not officially demarcated or "privatised" on the Mozambique side there has been a marked difference in the way land is used on both sides of the mountains – what Hughes (2001) terms "cadastral politics". Biodiversity conservation thus has to be approached differently in each country, with differing possibilities, problems and opportunities. Some of the conservation issues relating to the lowland forests on the Mozambique side are briefly discussed in Timberlake *et al.* (2016) and are not repeated here.

In Zimbabwe (then Rhodesia) there were a number of issues that faced the Melsetter community between 1892 and Zimbabwe Independence in 1980, but the biggest appear to be the poor state of roads, and hence great difficulties in travel as well as export of produce, and the continual recurrence of the tick-borne cattle disease, East Coast Fever, that effectively reduced the viability of any cattle industry. It is interesting to note from Sinclair's book (1971) that most communication and trade seems to have been with the large Rhodesian town of Umtali (now Mutare), some 100 km to the north (and to a lesser extent Chipinge), and very little with Mozambique. There was a Portuguese border post not far from Melsetter at the Mussapa Gap, manned by a Portuguese official who used to visit Melsetter for recreation and possibly supplies. However, Sinclair's book hardly refers to any use of the crossing by the settlers, although the Gap crossing was probably extensively used by the local African population who formed (and still form) a community on both sides of the border.

After the Second World War, there were renewed attempts to develop the Melsetter area and a number of important initiatives started up. Firstly, much land was bought by large companies such as the Rhodesian Wattle Company, as well as the Forestry Department (from 1954 this became the parastatal Forestry Commission), to create extensive plantations of pine (mostly *Pinus patula*), wattle (*Acacia mearnsii*) and gums (*Eucalyptus* species). Martin Forest Land was developed in 1945, followed in the early 1950s by Tarka, Chisengu, Lionhills and Glencoe. Later, secondary industries such as sawmills were established. It would seem that the conservation status of many of the Umkondo sandstone endemics (see Section 6.3) may have deteriorated at this time. Much of their somewhat open scrubby habitat would have been cleared for plantations. A lot of what had been small-scale mixed agricultural holdings with family-level production became more commercialised, roads became better and there was an influx of people. In 1949 the government Agriculture Department suggested the future of the District lay in small intensive mixed farming, mainly fruit and dairy, with commercial afforestation on sloping land. Arising from this, a 1500 acre Government Agriculture Research Station was established just outside Melsetter town on Lindlay North farm in 1949, but this was closed down in 1965.

In this immediate post-War period the Melsetter community also tried to develop tourism in the area, although it appears that this revolved primarily around local scenic and historical attractions (see Sinclair 1971) rather than the Chimanimani Mountains themselves. To an extent, the mountains were initially more of a backdrop to the Melsetter community than forming part of their lives; Sinclair's book has just passing mention of brief visits to the Bundi Plain over the first ridge, or of adventurous individuals such as the forester John Ball, an avid orchid collector, who spent time exploring it. For a few years in the late 1940s a farmer from Melsetter, Hendrik Olwage, used to take visitors up the mountains on ponies (Jane Browning, pers. comm.). The only mention of actual use is by Gideon Martin (after whom Martin's Falls were named, and probably also Martin Forest Land) who grazed his cattle up on the Bundi Plain on the Zimbabwe side around 1944 (Sinclair 1971, Dutton & Dutton 1975).

Of much greater significance for the Chimanimani Mountains themselves was the gazetting of the 20,213 acre (8186 ha) Chimanimani National Park in 1949, one of the first two declared in Zimbabwe (the other being Hwange). However, the actual justification or reason for this is not clear, nor is it clear if any land was compulsorily purchased although, for example, it appears that the farm Rocklands (possibly belonging to Gideon Martin) originally extended to a peak on the Mozambique border near what was then called Ben Nevis (now Mt Peza), as did the farm Dunblane. From historical accounts, including of Rawdon Goodier's first visit in 1956 (Goodier 2009), it seems that Dead Cow Camp and Long Gully, situated at the end of a motorable track near Charleswood Farm (just south of the present National Parks offices), was the main entry point. The Mountain Hut, situated in the middle of the Bundi Plain, was under construction in 1956, if not earlier. John Ball had a major role in its establishment (Jane Browning, pers. comm.). All the materials for this were brought in by porters or by donkey, and even at that early stage it was fully kitted out with paraffin stove and fridge, showers and bunk beds. There was also a ram pump for the water supply.

During the 1950s there were many school trips up the mountains, including one for ecological studies by a girl's school in 1957 (led by Jane Browning, pers. comm.). The Rhodesian Schools Exploration Society (e.g. Quaile 1973, Shaw 2012), and other schools such as Peterhouse, regularly used the mountains for trips, a use that continues to this day. Some of the more adventurous of these early school visits also involved multi-day trips through the Mozambique portion. Accommodation was primarily in the many caves found across the plateau, which has given rise to some of their names (see Annex 2).

Later on, the Outward Bound centre was established in 1961 at the foot of the mountains, north-east of Melsetter. This encouraged many more visits to the mountains by a wider range of people, including school children getting outdoor and leadership training.

As can be seen, the trajectory of "official" development, and thus conservation, was very different on each side of the mountain range with seemingly very little communication or exchange between the national authorities. A situation that, hopefully, the formation of the Trans-Frontier Conservation Area will help to address.

3.3 Conservation Situation and Initiatives

Straddling the border between Zimbabwe and Mozambique, with the border running down the long axis and a significant length of it following the watershed, the Chimanimani Mountains are effectively one ecological and conservation unit, and it is generally recognised that they need to be managed as such.

On the Zimbabwe side, all of the quartzite areas and much of the remaining lowland forest (which is very significant from a conservation viewpoint) lie within the 155 km^2 Chimanimani National Park gazetted in 1949. Some additional forested and dense woodland areas are protected in the Haroni and Rusitu Botanic Reserves adjacent to the Makurupini Forest at the far southern end (Timberlake 1994) or as Forest Land under the control of the parastatal Zimbabwe Forestry Commission (e.g. Martin and Tarka Forest Lands). Virtually all the areas of conservation interest within the Chimanimani complex south of 19°39'S are formally protected in Zimbabwe.

However, by far the larger part of the massif lies in Mozambique. There nearly all (but see Section 7.5) the upland areas of conservation interest now lie within the Core Area of the Chimanimani Trans-Frontier Conservation Area (TFCA, see next section), although a significant extent of lowland forest, also of great conservation importance, lies within the TFCA Buffer Zone where human settlement and land use is allowed (see Timberlake *et al.* 2016).

The TFCA Core Zone in Mozambique is called the Chimanimani National Reserve (Reserva Nacional de Chimanimani) under recent legislation (República de Moçambique 2003), and is meant to be a zone of total protection of certain species (rare, endemic, in decline) or fragile ecosystems. This is a very similar status to a National Park (Parque Nacional) but where a limited amount of human use is allowed under licence, for example utilization of natural resources, as long as it is included in the management plan and is compatible with the overriding protection objectives. However, it would appear that no people can live inside a National Reserve, which seems to be equivalent to IUCN Protected Area Category II. It is not clear why the Chimanimani massif was gazetted as a National Reserve and not a National Park, but this may be because as well as a Core Zone there is an adjacent Buffer Zone within the broader TFCA.

All protected areas in Mozambique now fall under the Conservation Directorate of the large Lands, Environment and Rural Development Ministry (Administração Nacional das Áreas de Conservação (ANAC), Ministerio da Terra, Ambiente e Desenvolvimento Rural).

The first mention of protection for the Mozambique side of the Chimanimani appears to have been in 1953 by the Chef do Posto (administrator) in Mavita, four years after the establishment of the National Park on the Zimbabwe side, but nothing was apparently done. A bit later, at the 1966 AETFAT Congress, the botanist Grandvaux Barbosa listed what he regarded as the botanical conservation priorities for Mozambique (Barbosa 1968). He recognised that the Chimanimani Mountains contained "endemic montane vegetation" and that a National Park, adjoining the one already in place in Zimbabwe, was required for its conservation, and he also clearly brought out the necessity for conservation of the associated moist forests on the footslopes, although some Forest Reserves (Maronga, Zomba, Moribane; Gomes e Sousa 1968) were already in place. Although not strictly conservation, there was also cooperation between the Rhodesian and Portuguese authorities in 1969 over wildfire and veterinary controls (Bannermann 2010).

The first major initiative in this regard came from Paul Dutton (Dutton & Dutton 1973) in his survey of the area for the colonial Veterinary Department (then the body responsible for biodiversity conservation) just before Mozambican Independence. A map was produced (Mapa 2) showing suggested boundaries for, initially, a core area (Zona de Vigilância) above the 1000 m contour from near Mt Peza in the north to the Haroni/Mukurupini rivers in the south and also including the separate Mt Mucota area just north of Mavita. This was to be followed (second phase) by a broader area extending from the Rio Mussapa Pequeno, along the Rio Mussapa and, avoiding areas that were heavily settled, across the pediplain west of the Rio Mussapa to a point perhaps 15 km downstream of the Zimbabwe border along the Rio Lucite. The proposed area included the gazetted Maronga and Zomba Forest Reserves, but not Moribane Forest Reserve.

Independence was gained in 1975, followed later by political instability. Thus it was only in the mid-1990s that attention appeared to return to the Chimanimani area and its conservation, attention that was now focussed on the idea of a trans-frontier conservation area.

3.4 Chimanimani Trans-Frontier Conservation Area

The process towards the establishment of a Trans-Frontier Conservation Area (TFCA) was initiated when Richard Bell was employed as a consultant for the National Directorate of Forests and Wildlife and The World Bank/Global Environment Facility to draw up plans for a conservation area to be called the Nakaedo Biosphere Reserve (Bell 1999). Unfortunately, only incomplete documentation appears to remain on this (see Ghiurghi *et al.* 2010a, vol. 1, p.7). As with Dutton & Dutton's proposal, there was to be a core conservation zone in the highlands above 1000 m altitude with its boundary from Chimanimani camp at the source of the Rio Mussapa Grande, along the foot of the high escarpment eastwards and southwards past Mahate to Zomba, then along the foothills of the southern escarpment south-eastwards to Maronga and the Haroni–Rusitu confluence. However, unlike the initial suggestions from Dutton and Dutton (1973), Mt Mucota was excluded whereas the uplands by The Corner and the southern Rotanda area were to be included. This core zone was to be surrounded by an outer zone of lower conservation priority in the surrounding mid- and lower altitude areas, based on the rationale that the highlands were more-or-less uninhabited and had very high aesthetic and biological values. The outer zone, by contrast, was relatively heavily settled and of lower aesthetic value, although it contained high biodiversity value in the form of the remaining lowland forests. However, nothing further seemed to happen at that time with this initiative, possibly due to Richard Bell's untimely death.

Later, in the 2000s and with support from The World Bank, the whole Chimanimani area was designated as the Chimanimani Transfrontier Conservation Area, approximately 4091 km^2 in extent (Anon. n.d.). In Mozambique this initiative received extensive support from the Peace Parks Foundation and The World Bank from the late 1990s to around 2012. Although there appears to have been little funding or activity on the Zimbabwe side over that period, existing management and investment by the Zimbabwe Parks and Wildlife Authority has ensured that the biodiversity values of the Chimanimani National Park have been retained there, even in the face of an invasion of illegal gold miners (see Section 7).

The TFCA in Mozambique comprises a Core Zone, where no settlement or extractive use is allowed, and a Buffer Zone (Figure 3.1). Natural resource management and some economic activity is allowed in the Buffer Zone as long as it is felt to be not incompatible with conservation objectives (equivalent to IUCN Category VI), and conservation issues should form a significant part of land use and economic planning.

In Mozambique the core conservation zone was originally gazetted in 2003 as the Reserva Nacional de Chimanimani (República de Moçambique 2003) with a calculated total extent of 640.6 km^2 (area determined from digitised version of gazetted points) The boundaries have recently been re-defined (República de Moçambique 2013 with a full list of UTM coordinates) owing to land use and subsequent human intrusion, and now has an extent of 660.2 km^2 (area calculated from gazetted points and following international border; this differs from the 645 km^2 in Anon. n.d. [GIZ]). In both cases (2003 and 2013) the perimeter is approximately 181 km long. The main changes between 2003 and 2013 were that the new boundary now lies 1–5 km further away from the top edge of the massif to the south-east, the included area around Nyabowa community in the north is somewhat more extensive, and the northern extremity around The Corner is significantly smaller, being confined to higher rockier ground. The Core Zone now covers land above 350 m altitude in the south and 600–

800 m in the north. The initial intention was that the Core Zone would primarily consist of land above 1000 m altitude (Dutton & Dutton 1976, Zona de Vigilância).

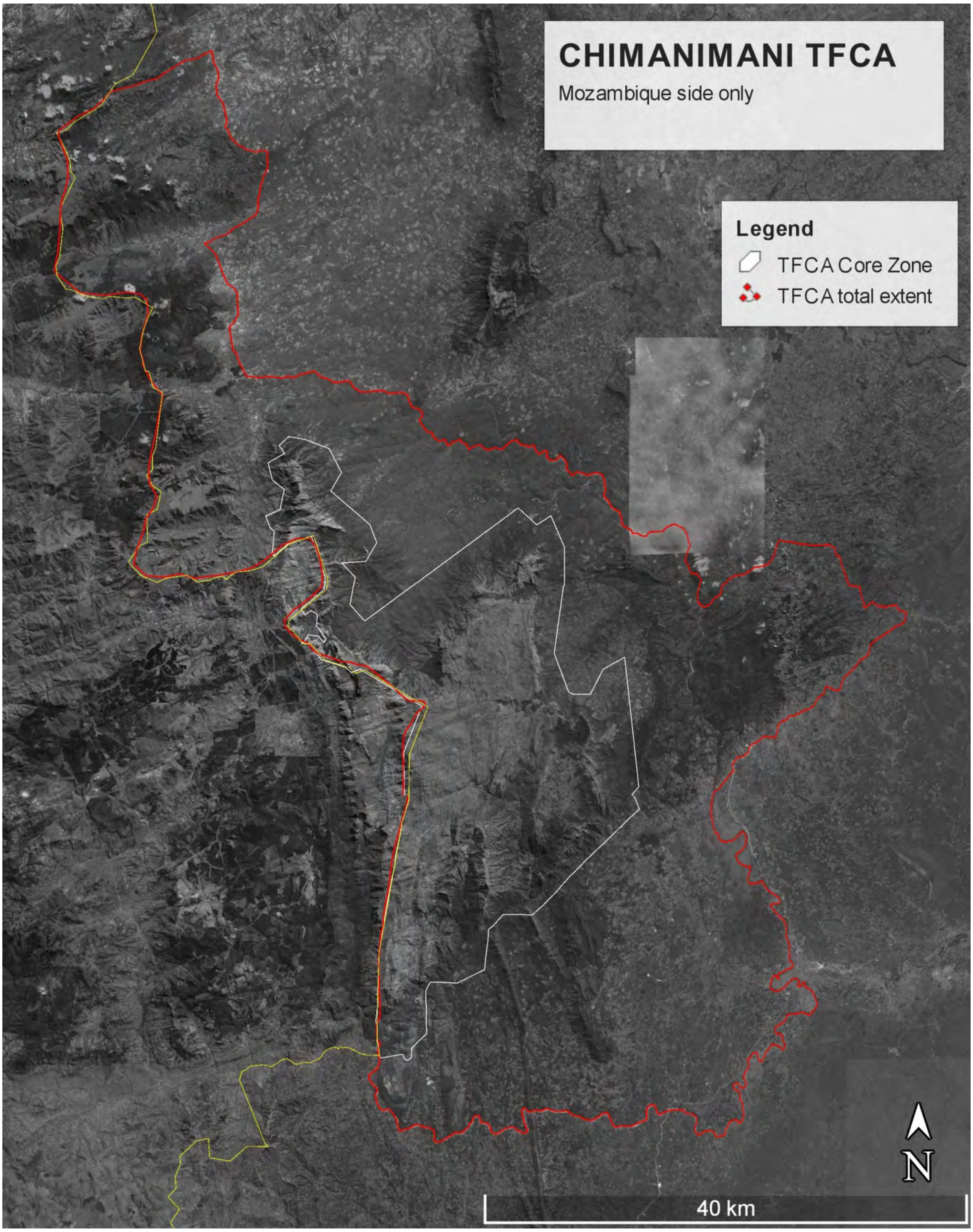


Figure 3.1. Boundaries of Chimanimani TFCA core zone (revised) and buffer zone in Mozambique (Google Earth image). The main quartzite mountains on both sides of the border are seen from their lighter colour.

To the south, east and north, the Core Zone is surrounded at lower altitudes by an extensive Buffer Zone (Zona Tampão) covering a larger area of 1721.4 km^2 (from digitised version of gazetted points, minus extent of Core Zone). This extends eastwards from the Chimanimani foothills to the Rio Lucite in the south, the Rio Mussapa in the east, and northwards to Mt Tsetserra (see Ghiurghi, Dondeyne & Bannerman 2010a). Three Forest Reserves, originally gazetted in 1953 for timber production – Maronga, Zomba and Moribane – lie in the Buffer Zone (see Timberlake *et al.* 2016).

On the Zimbabwe side the TFCA core zone comprises the Chimanimani National Park (155 km^2) and the small Eland Sanctuary (15 km^2) above the town of Chimanimani (Anon. n.d. [giz]). It is not clear how far the buffer zone extends or if any Forest Land is included.

Although in the recent past, cross-border collaboration within the TFCA as regards conservation management between the two countries has been limited, this now appears to be increasing (Muassinar 2015).

Anthony Mapaura with *Leucospermum saxosum* [BW].

Plant collecting on steep quartzite slopes, N Chimanimani [JT].

4. PREVIOUS BIOLOGICAL WORK

There are a large number of publications and studies on various aspects of the biology and conservation of the Chimanimani Mountains and the associated lowlands. Most of these are cited in the bibliography (Section 11). Below we outline the main botanical and ecological studies, those on the montane and lowland forests (see Timberlake *et al.* 2016 for more on the latter) and the phytogeographical ideas that the Chimanimanis have added to. Brief details on what is known of vertebrate life are given in Section 4.5.

4.1 Previous Botanical and Ecological Studies

The Chimanimani area and the general Manica Highlands region along the Zimbabwe–Mozambique border (in Zimbabwe usually called the Eastern Highlands) have a relatively long botanical history. Indeed, the first publication on the botany of Rhodesia (now Zimbabwe) was that by Rendle *et al.* (1911) documenting Charles Swynnerton's botanical collections from "Gazaland", the name given to what are now the districts of Chimanimani and Chipinge in Zimbabwe and adjacent parts of Mozambique. At that time Swynnerton was based at Gungunyana Farm, now part of Chirinda Forest (Timberlake & Shaw 1994). In this publication a number of species and 11 new taxa were described from the Chimanimani mountains and Mt Peza areas of Zimbabwe. A later publication by Gilliland (1938) on the vegetation of Rhodesian Manicaland, despite its title, did not cover mountains south of Mutare.

The resurgence of botanists visiting the Chimanimani mountains just after the Second World War up until the mid-1950s, although resulting in many collections and in a few new species being described, did not initially seem to produce any comprehensive picture of the botany or ecology of the mountains, although its botanical richness and interest was obviously fairly widely known (Jane Browning and Jim Phipps, both pers. comm.). Raymond Munch collected there in the late 1940s, while in the early 1950s Paddy Crook and his wife Lucy Chippendall (a South African grass specialist) collected there, as did Darrel Plowes and John Ball, the latter particularly focussing on orchids (see Table 4.1). The high levels of endemism were something that was surely recognised, but just not written about.

This started to change in 1956 when Rawdon Goodier, then a young tsetse ecologist based in the Zambezi Valley, started visiting the mountains to rock climb (Goodier 2009, R. Goodier pers. comm., April 2015). He later teamed up with Jim Phipps, a botanist working at the Government Herbarium in Salisbury (now Harare), who had similar interests (Figure 4.1). Over the next 3 to 4 years they paid many visits to the mountains and collected systematically, building on the earlier extensive collections of Hiram Wild and R.C. Munch (1944–1950). Schools expeditions also went up the mountains (e.g. Mitchell *et al.* 1958, Quaile 1973, Shaw 2012) and collected.

In 1958 Goodier and Phipps produced a preliminary checklist listing 573 species found above 1200 m in the area underlain by rocks of the Frontier System (quartzite and schist). Following further plant collections this was revised in 1961, listing 859 taxa (Goodier & Phipps 1961). The latter list was also republished as an appendix in Dutton & Dutton (1975) but, surprisingly, no further similar lists have since been produced. Much later the National Herbarium in Zimbabwe produced a list of 2182 species based on their databased collections of all species recorded in Chimanimani District (Chapano & Mamuto 2003), but this covers species both on and away from the mountains and with no means to distinguish between them. However, building on the initial Goodier and Phipps checklists, a revised list is now under preparation for the area above 1200 m (Wursten, Timberlake & Darbyshire, in prep.) that will also incorporate recent collections under this CEPF project.

Figure 4.1. Jim Phipps (L) and Rawdon Goodier (R), Harare 1961 [R. Goodier].

On the ecological side, Goodier & Phipps produced a sketched vegetation map of the Chimanimani Mountains, mostly of Zimbabwe (Goodier & Phipps 1962), but their main work was an account of the ecology of the mountains in the Journal of Ecology (Phipps & Goodier 1962). This very detailed and comprehensive study discussed not just the mountains and their endemic flora, but also the possible reasons for it, and linked geology and soils to plant distribution. Nothing published since has superseded it.

Following on from Phipps & Goodier, the last significant studies on Chimanimani botany until recently were by Wild (1964, 1968) on the endemic flora and phytogeography. In his 1964 paper, based upon the collections of Goodier and Phipps as well as his own, Wild described a number of new species (some in conjunction with other experts) and discussed the significance and origins of this endemism "hot spot". Later he looked at the phytogeography of south-central Africa as a whole (Wild 1968) and the place of the Chimanimanis in it (see Section 4.4).

In the later 1960s through to Zimbabwean Independence in 1980, there were quite a few collectors visiting the mountains (James Whellan, Keith Coates Palgrave, Oliver West, Rosemary Grosvenor, Bob Drummond, Rob Kelly, Brian Simon, Tom Müller and Blake Goldsmith), and some expeditions (Peterhouse in 1971, Quaile 1973), but documentation is limited. Also at this time, interest started to be focussed on the lowland forests of the Haroni–Rusitu area (see below), possibly as access there became better.

From a conservation viewpoint, the area in Zimbabwe was well-protected and relatively easy of access from Chimanimani town. However this was not the case in Mozambique. Paul and Elizabeth Dutton made an extensive study of the larger Mozambique portion of the mountains and proposed the formation of a protected area (see Section 3.3). Their published document (Dutton & Dutton 1973) included much information on its natural history, including plants (much of it taken from Phipps & Goodier's publications). Written in Portuguese, this must have been a very useful document that brought attention from the Mozambique authorities to the area. It also appears to be the first publication to provide much information on the vertebrates, as well as being the first to focus on the Mozambique side.

In 2002, under the Sabonet (Southern African Botanical Diversity Network) project, all species that were believed to be endemic (or near-endemic) to Zimbabwe were listed and provisionally assessed at a national level in a workshop (Golding 2002, Mapaura & Timberlake 2002). This was later written up more systematically by Mapaura (2002). In the Sabonet publication, most of the Chimanimani quartzite endemic taxa were nationally assessed as Lower Risk near-threatened as they were believed to be found over a comparatively large area, albeit very restricted, well-protected within a National Park and with no real threats. If a species was thought to be restricted to a specific peak or a more marginal habitat, it was considered Vulnerable D2. In a similar exercise for Mozambique in the same publication, a lower number of the known Chimanimani endemics were assessed as

Vulnerable (VU D2), with a few as Data Deficient (Izidine & Bandiera 2002). There did not appear to be any attempt to harmonise either listed species or conservation assessments.

Mapaura (2002) considered the Chimanimani mountains to be one of Zimbabwe's 13 biogeographical areas of endemism, but by far the largest in terms of number of species as there are 33 Zimbabwe endemic and 37 near-endemic taxa (i.e. taxa known from the Zimbabwe side of Chimanimani but also recorded in Mozambique). Overall, there were 55 taxa recorded only from the "quartzite grasslands" of the Chimanimani Mountains.

More recently, on the Mozambique side, the Chimanimani Management Plan for the TFCA has an appendix of rare and endangered plants listing 265 taxa (Ghiurghi, Dondeyne & Bannerman 2010b, Annex 6). It is not clear how this was compiled but it appears to have been based on the Sabonet list for Zimbabwe. An additional output of this management plan was a photographic guide illustrating many of the plants of interest (Dondeyne, Wursten & Bannermann 2009), each photo with locality details. Unfortunately, this does not appear to have been produced in hardcopy and is only available digitally.

Finally, linked in with the current CEPF study, Toral Shah wrote her MSc thesis on the conservation of four contrasting endemic species on the Mozambique side (Shah 2016), using habitat as a proxy in modelling their conservation status.

From a review of the literature, one question not yet fully answered is when it was first realised that the Chimanimani Mountains supported such a significant number of endemic species; descriptions of new taxa only really started appearing in the 1950s. There appears to be no mention of such species until Goodier & Phipps (1958), and nothing explicit until Wild (1964). When was it suddenly realised this was an area of high endemism, possibly with new species still to discover?

4.2 Moist Forest Studies

As part of his comprehensive study on moist forests in Zimbabwe, Tom Müller (1999, 2006; see also Appendix 4 in Ghiurghi *et al.* 2010a) maps and describes forest patches (patch numbers 68, 78–88, 102–105) in the Chimanimani Mountains area in Zimbabwe, although most of these are rather small. The altitude at which they can be found, and hence the forest type, varies from 350 m to over 2000 m. Most of the higher altitude patches (above 1000 m) are types 5 and 7, with smaller extents of types 4 and 8. Type 5 is *Syzygium guineense* subsp. *afromontanum* montane forest (from 1500–1900 m), while Type 7 is Mixed submontane forest (with elements of medium altitude forest such as *Chrysophyllum gorungosanum*, generally 1600 up to 1750 m). Type 4 is *Ilex mitis–Schefflera umbellifera–Maesa lanceolata* montane forest, where conditions are too dry for either *Syzygium* species to dominate, and Type 8 is forest dominated by *Craibia brevicaudata*. The latter is nationally quite scarce, being known only from the Chimanimani and Vumba areas (generally at 1400–1600 m). From his Table 2 (Müller 2006) there are 190 ha of moist forest within the Chimanimani National Park and an additional 225 ha in the broader Chimanimani area, plus 425 ha in the lower altitude Haroni–Rusitu–Chisengu rivers area.

Lowland Forests

Although not part of the Chimanimani montane flora, the forested areas on the lower slopes are of great conservation significance. In Zimbabwe the Mukurupini Forest (at the southern tip of the Chimanimani National Park) and the Haroni and Rusitu Botanic Reserves in the lower Rusitu valley have been the focus of many biological trips since the early 1960s. These are almost the only remaining examples in that country of lowland moist forest (Timberlake 1994), although such forests are far more common in Mozambique along the eastern

Chimanimani foothills. Further details of the Mozambican forests can be found in a botanical and conservation report prepared under the Darwin Initiative project implemented by Micaia and RBG Kew in 2014–2017 (Timberlake *et al.* 2016), but are not specifically looked at under this CEPF project.

One early published account of the Haroni–Rusitu junction area came out of a Rhodesian School's expedition visit in April 1973 ('Vakwashi') to what was then a remote roadless area (Magness *et al.* 1973), including a section on the botany. A map was produced based on aerial photos showing the main forest patches. They found that the main and dominant tree was *Newtonia buchananii*, also with numerous lowland forest tree species, with a canopy 40–60 m high. On steeper slopes a *Brachystegia microphylla–Uapaca kirkiana* woodland was seen. Ten new records for Zimbabwe were found, and a checklist was produced of 240 taxa (including cultivated species and arable weeds).

Gerald Pope and Tom Müller studied the lowland forests in the Mukurupini area at the southern end of the Chimanimani and along the foothills on the Mozambique side in April 1974, from which the checklist of woody plants published in Dutton & Dutton (1975; Appendix A) comes, but this did not cover montane areas. Later, a checklist of all plants recorded was compiled for the Haroni–Rusitu junction area in Zimbabwe based on a manuscript dating from the 1970s in the Harare Herbarium (Timberlake 2000, unpublished). Although quite a few Chimanimani endemics are listed there, showing that their distributions are not solely montane, it is not clear what the altitudinal limits of the original list were.

A Visitors Guide to the Haroni–Rusitu–Makurupini area of Zimbabwe was in the process of being prepared in 2000 by a Zimbabwean NGO, the Biodiversity Foundation for Africa, to be published as a small book. However, this never reached completion, partly because of Zimbabwe's political and economic problems soon after. A number of chapters – on ferns, orchids, plants, vegetation, fish, butterflies, mammals – were written or are in various stages of completion (Timberlake, pers. comm.).

4.3 Botanical Collectors

As part of this CEPF project, all collections of the known Chimanimani endemics, near-endemics and what were believed to be range-restricted species found in the Chimanimani mountains and upland areas of Chimanimani District held at Kew and at the Harare Herbarium (SRGH) were databased using the BRAHMS herbarium database program (Filer 2016). Collections of all species from the 2014 expeditions were later added in (collections from the 2016 expedition will be added later). Once corrected, this database, now containing 2153 records with 1687 of them from the broad Chimanimani area, was used as the source of the observations below. Although the database only covers records of the selected species, it is believed to give a good indication of collectors and collecting patterns, especially as it is these species of particular interest that most plant collectors would be targeting.

Over half (50.9%) of the 1158 pre-2014 collections from the broad Chimanimani area in the database were collected between 1948 and 1960, in what could be considered the heyday of collecting in the mountains. Almost 81% were collected in the slightly broader period of 1948 to 1970, with just 106 collections between 1905 and 1947, and a further 106 between 1971 and 2013. Surprisingly, there were only 12 collections from the period between 1990 and 2013, including just one since 2000 (in 2011).

Mozambique

As can be seen from the list of the main Chimanimani collectors in Table 4.1, there have been significantly fewer plant collections from Mozambique over the years than from Zimbabwe, probably due to the great majority of collectors being Zimbabwe-based. But also because the area covered by the Kew database covers the non-montane farming areas around Chimanimani as well as the mountains themselves, giving a bias in collection numbers.

Table 4.1. Botanical collections and collectors in the Chimanimani area 1906 to 2016 (data from RBG Kew database of endemic and near-endemic species only).

Collector/s	**dates**	**country**	**area**
Johnson, W.H.	1907	M	'Moribane' (The Corner?)
*Swynnerton, C.F.M.	1906–1908	M, Z	Chim Mts, 'Melsetter', Mt Pene
Cooper, J.C.	Aug 1921	Z	'Melsetter'
Cronwright, W.	May 1923	Z	Chim Mts
Weiste, Miss	May 1942	Z	Chim Mts
Finlay, R.H.	Sep 1944	Z	Chim Mts
*Munch, R.C.	1944–1948	Z, M,	Chim Mts, Chim foothills
Wild, H.	Apr 1947	Z	Orange Grove
McCosh, F.W.J.	May 1947	Z	Chim Mts
Chase, N.C.	Dec 1948, 1953	Z	Pork Pie, Chim farms
**Wild, H.; Munch, R.C.	Jun 1949	Z, M	Chim Mts, Bundi valley
Pedro, J.G.; Pedrogão, J.	Jul 1949	M	Chim Mts, Mt Messurussero
Thompson, S.	Jul 1950	Z	Chim NP
*Crook, A.O.	1950–1953 (various)	Z, M	Mussapa Gap, Chim farms, Corner
**Wild, H.; Chase, N.C.; Munch, R.C.; Plowes, D.C.H.; Sturgeon, K.E.; Panton, C.A.	Oct 1950	Z, M	Mussapa Gap, Mt Peza, Corner, Pork Pie
Guy, G.L.	Apr 1951	Z	Chim Mts
Finch, R.	Aug 1951	Z	Corner
*Ball, J.S.	1953–1963, 1973	Z	Chim Mts, Chim farms (mostly orchids)
Wild, H.	Aug 1954	Z	Chim Mts
Leach, L.C.	1954–1961	Z	Chim Mts, Chim farms
Watmough, R.	Sep 1955	Z	Chim Mts
Drummond, R.B.	Nov 1955	Z	Glencoe FR, Mt Pene
Barrett, R.L.; Stables, J.H.	Dec 1955	Z	Chim Mts, Mussapa Gap
*Taylor, H.C.	Sep 1956	Z, M	Chim Mts, Mt Binga, Martin's Falls, Skeleton Pass
Coates Palgrave, K.	May 1956	Z	Chim Mts
**Goodier, R.; Phipps, J.B.	1957 (various), 1959 (various), 1960 (various)	Z, M	Bundi valley, upper Haroni, Mt Dombe, Mt Binga, Mt Peza, Mussapa Gap, Mawenje, Skeleton Pass, Mt Nhamadimo, Martin's Falls
*Chase, N.C.	Apr 1957, May 1958	Z	Mt Pene, Chim Mts
Whellan, J.A.	Apr 1957	Z	Chim Mts
Garley, D.L.	Aug 1957	Z	Chim Mts
*Hall, A.V.	Feb 1958	Z, M	Bundi plain, Mt Binga, Martin's Falls
*Chase, N.C.	May 1958, Nov 1965	Z	Bundi plain, Outward Bound
*West, O.	May 1958, Sep 1965	Z	Skeleton Pass, The Corner
*Noel, A.R.A.	May 1959	Z	Chim lower slopes, Bundi plain, Skeleton Pass
*Loveridge, J.P.	Sep 1961, Jun 1966	Z	Chim Mts, Chim farms

*Plowes, D.C.H.	1962 (various)	Z	Chim Mts
*Whellan, J.A.	Aug 1964, Dec 1964, May 1965	M, Z	Bundi valley, Mawenje, Martin's Falls, R. Mufomodzi, Saddle
Wild, H.; Goldsmith, B.; Müller, T.	Dec 1964	Z, M	Mukurupini
*Corby, H.D.L.	Jul 1965, Feb 1968	Z	Chim foothills, Chim farms
Coates Palgrave, K. *et al.* (school expedition?)	Aug 1965	Z, M	S Chim Mts, Mt Mahoenzi
Torre, A.R.; Perreira, A.	Oct 1965	M	Rotanda
Perreira, A.; Sarmento, A.; Marques, A.	Jan 1966	M	Mt Binga
*Grosvenor, R.K.; Drummond, R.B.; Simon, B.K.; Plowes, D.C.H.	Sep 1966	Z, M	Outward Bound, Bundi plain, Mt Binga, Skeleton Pass, Camp Portage
*Grosvenor, R.K.; Drummond, R.B.; Plowes, D.C.H.	Apr 1967	Z, M	Outward Bound, Bundi plain, Skeleton Pass, St George's cave, Saddle
Grosvenor, R.K.	Sep 1967	Z	Chim Mts
*Mavi, S.; Müller, T.	Nov 1967	Z, M	Mussapa Gap, Chikukwa, Martin FR
*Simon, B.K.; Ngoni, J.F.	Nov 1967	Z, M	Ngorima, Mukurupini
*Goldsmith, B.	1968–1973	Z	Tarka FR, Mt Pene, Chim Mts
Kelly, R.D.; Simon, B.K.	Apr 1969	Z	Bundi plain
Müller, T.; Kelly, R.D.	May 1969	M	Mukurupini, S Chims
Wild, T.M.	Aug 1969	Z, M	Mukurupini
Plowes, D.C.H.	Oct 1970	Z	Skeleton Pass
Müller, T.; Gordon, T.A.D.; Pope, G.	Jun 1971	M	Mukurupini
Ngoni, J.F.	Apr 1973	Z	Haroni-Rusitu
Dutton, P.	1973	M	Chim Mts
*Bamps, P.; Symoens, J.J.; vanden Bergen, C.	Jan 1974	Z	Chim Mts, Mt Pene
Beasley, A.J.	Mar 1974	M	R. Mufomodzi
Pope, G.; Müller, T.	Apr 1974	M	Chim foothills
Müller, T.	Aug 1975, Aug 1977	Z	Mukurupini, Mt Pene
Philcox, D.; Leppard, M.J. *et al.*	Mar 1981	Z	Chim lower slopes, Mt Pene
Burrows, J.E.	Sep 1981	Z	Chim Mts
Müller, T.; Best, B.	Nov 1983	Z	Chim Mts
Linder, H.P.	Nov 1986	Z	Chim Mts
Carter, S.; Coates Palgrave, M.	Aug 1988, Jun 1994	Z	Corner, Chim foothills
**Timberlake, J.R.; Ballings, P.; Wursten, B.; Hadj-Hammou, J.; Mapaura, A.; Matimele, H.	Apr 2014	M	Chim Mts, Mt Pene, Mt Nhamadimo
**Timberlake, J.R.; Wursten, B.; Mapaura, A.; Mutasa, K.; Chelene, I.	Oct 2014	M	Chim Mts, R. Mufomodzi
**Timberlake, J.R., Mapaura, A., Banze, A., Osborne, J., Shah, T., Massunde, J., Fijamo, V.	May 2016	M	Chim Mts, R. Mufomodzi, Mt Binga, Mt Nhamadimo, Saddle

Note: Entries marked with a single asterisk are significant collections in terms of numbers (more than 15); those marked with a double asterisk have more than 50 collections in the database. Some collectors other than those listed here have collected in the Chimanimani area, but with only single or very few database entries.

Of the 1687 collection records in the Kew database from the broad Chimanimani area on both sides of the border, only 699 (41%) are from Mozambique. But of that Mozambique total, over three-quarters (528) are from the CEPF 2014 Mozambique expeditions, which therefore represents a four-fold increase in our knowledge. And there have been around another 400 collections since then (see Section 6.1). Up to the recent CEPF collections, there were only 171 records from the Mozambique side of the Chimanimani Mountains, just 15% of total pre-2000 collections.

The first collections in Mozambique were by W.H. Johnson in 1907 from what he called the "Moribani" area. Moribane is now regarded as a lowland forest area although the species he collected included some quartzite endemics. Given the main travel routes at that time, it is probable that his collections were actually from the Mussapa Gap area near the present-day Zimbabwe border at around 1000–1200 m. There are no further Mozambique entries until R.C. Munch collected montane species in June 1948, including a number of the endemics, and he later collected with Hiram Wild in June 1949. This was followed by a significant set of collections from a cross-border expedition with Wild, Munch, Norman Chase, Darrell Plowes, Kathleen Sturgeon and C.A. Panton in October 1950, the first of the larger trips with a number of botanists participating. Slightly earlier, in July 1949, J.G. Pedro and J. Pedrógão collected in the mountains including Mt Messurussero, but there was very little collecting afterwards until H.C. Taylor entered Mozambique on what was primarily a Zimbabwe field trip in September 1956, as did A.V. Hall in February 1958.

The main collectors on the Mozambique part of the mountain over the pre-Independence period were Rawdon Goodier and Jim Phipps, both based in Zimbabwe. They collected over much of the Chimanimani range on both sides of the border, but in Mozambique only in December 1959 and April 1960. After that period, other significant collections from Mozambique were made by J.A. Whellan in 1964 to 1965 in the montane part, by Hiram Wild, Blake Goldsmith and Tom Müller in December 1964 from the lowland Haroni–Mukurupini area, and two cross-border trips by Rosemary Grosvenor, Bob Drummond, Brian Simon and Darrell Plowes in September 1966 and April 1967. The only Portuguese botanists we have records from this period were A.R. Torre & A. Perreira, collecting in the Rotanda area in October 1965, and Perreira, A. Sarmento and A. Marques who collected on Mt Binga in January 1966.

Although some studies were carried out on the flora (e.g. as seen in Dondeyne *et al.* 2009 and Ghiurghi *et al.* 2010a), no significant collections appear to have been made in the mountains from 1975 until the CEPF trips in 2014. At this time, numerous collections were also made by Kew and IIAM botanists (Banze, Cheek, Darbyshire, Fijamo, Massunde, Timberlake) in the forested Chimanimani foothills in 2015 as part of a Micaia–Kew Darwin Initiative project. A partial checklist is available (Timberlake *et al.* 2016, Annex 2).

4.4 Phytogeography

Surprisingly, the phytogeography of such a fascinating flora as that along the mountains of the Zimbabwe–Mozambique border, in particular the Chimanimanis, has been discussed very little. Weimark (1941, cited in Wild 1964) first showed that the flora of these borderland mountains was significantly different from that of the surrounding plateau-lands (the Highveld), yet quite similar to that found on mountains in the Western Cape in South Africa. Wild (1964) also considered the flora similar to that of the Drakensberg mountains in the former Natal and Transvaal, as well as to that found in Malawi (Kirk Highlands, Zomba, Mt Mulanje, Viphya plateau). However, two big geographic disjunctions – the Zambezi Gap and the Limpopo Gap – were recognised. Later, building upon the geomorphological and continental erosion thinking of King (1962), which was elaborated upon by Lister (1987), Wild (1968) suggested that any species common across the mountains must not only have evolved before the formation of the much hotter and arid gaps but also must have been part of a more-or-less continental belt of more mesic forest vegetation in the distant past.

Wild (1964) suggested that what he termed the Inyangani Subcentre (Nyanga + Chimanimani) separated from the Drakensberg, Cape and Mulanje subcentres more than 1 to 2 million years ago (mya), and went on to suggest (Wild 1964, 1968) that the Cape Flora (or a direct evolutionary precursor) covered a large continuous area of the African continent up to the early Tertiary (c. 50 mya). But that before the beginning of the Quaternary (c. 1.5 mya) this had become very fragmented and remained only in montane areas. He thought that the endemism had developed over 60–70 million years.

Broad phytogeographical patterns for the montane areas of eastern and southern Africa are discussed at length by White (1978), with much of the detailed thinking outlined in a specific Malawian study (Chapman & White 1970). A specific Chimanimani "island" is recognised by White (1978) within his broader Afromontane archipelago-like regional centre of endemism, but his focus is mostly on the trees and forest vegetation. He does mention an Ericaceous Belt, which seems closest to the upland parts of the Chimanimani Mountains; this is discussed further in Section 5.1. However, although Killick (1978) in the same publication does not consider that any part of Zimbabwe or Mozambique falls in his Afro-alpine Region, the descriptions in particular of the Drakensberg subalpine belt seem very close to what is found above 1500 m on the Chimanimani massif.

Although the Chimanimani Mountains did not fulfil the full criteria required in their centres of plant diversity study – areas with over 1000 species and at least 10% endemism – Davis, Heywood & Hamilton (1994) provide a short description of both the Chimanimani (Af 79) and Nyanga mountains. A few years later Van Wyk & Smith (2001) clearly identify the Chimanimani and Nyanga area as being a single centre of endemism, and give a brief account of the broad area and discuss some of the flora's evolutionary history and links to the Drakensberg Mountains and the Cape Floristic Region. The long-standing nature of the mostly grassland endemics is also pointed out, indicating that such grasslands have been around for a long time.

Most recently, in his overview of the evolution of African plant diversity, Linder (2014) has suggested that the Chimanimani forms part of the Austro-temperate flora, an outlier of the Cape flora, characterised by Restionaceae, Proteaceae and taxa typical of the Drakensberg grasslands. It is not part of what he calls the Tropic-montane flora, which White (1983) calls Afromontane. This flora, he says, dates back to the Paleogene to Eocene (perhaps 35–50 mya). However, Linder recognises that there are bound to be some common elements such as *Cussonia* and *Erica*.

Given our greatly improved knowledge today on continental drift, on the comparative ages of plant genera and on paleoclimates, some of the earlier phytogeographical interpretations would seem to fall away. Surprisingly, Wild did not seem to accept a major role for long-distance dispersal either. However, to date he has been the only person to publish anything on the type of vicariant endemism (closely-related or allopatric species that have descended from a common ancestral population and attained spatial isolation) found on the Chimanimani mountains. He pointed out the difference between the vicariant endemics and those that were sympatric (occurring together); in the latter the two species must be incompatible from a breeding viewpoint.

Wild also recognised clearly (Wild 1964, 1968) that almost all of the Chimanimani endemics were confined to quartzite substrates with very few being found on schist or on both (an exception being *Aeschynomene inyangense*). He suggested that the lower available phosphorous levels in soils derived from quartzite, and the significantly lower soil fertility, must be major factors in causing speciation through ecological stress. Some species such as *Erica johnstonii* occur on most mountains from Chimanimani to Mt Mulanje, while others are confined to quartzite soils. He listed 10 taxa pairs known at that time where one species is confined to the Chimanimani while a closely related one is more widespread. It is of interest to note that the species from which each of these particular Chimanimani endemics has probably evolved are spread across families and in their geographical distribution, and Wild found no clear phytogeographical patterns.

Other than the discussion in Van Wyk & Smith (2001), no further work since Wild appears to have been done on the phytogeography and origins of the Chimanimani flora. Given our new findings, it is hoped that further research will now be stimulated.

4.5 Wildlife Studies

Compared to plants and vegetation much less has been written about the vertebrate and invertebrate wildlife of the mountains. In the recent past the extensive grasslands and open areas were renowned for large herds of Eland and Sable antelope, but owing to hunting by the small-scale miners since the mid-2000s these have mostly disappeared. Phipps and Goodier (1962) mention Klipspringer, Eland and Sable antelope as being the main grazers, with baboons and Rock Hyrax also common. Large mammals used to roam freely across the border but, according to the Reserve Warden (pers. comm., Nov 2014), the remaining animals have now moved to more wooded areas at slightly lower altitudes in the east and north east where there are fewer people. During many weeks of fieldwork in 2014 and 2016, almost no antelope were seen, although evidence of small carnivores was noted. A species of particular interest is the Aardvark or Ant bear (*Orycteropus afer*), the dug holes of which provide an unusual habitat across the grasslands, one that is often used by Blue Swallows for their nests (Little 2013). Numerous Aardvark holes were seen during our survey, but it was not checked if these were still occupied, either by Aardvarks or Blue Swallows.

The main published work on wildlife is that by Dutton and Dutton (1973). In their appendices they provide lists of 67 mammals (including rodents and bats) compiled by Reay Smithers and José Lobão Tello from museum collections and survey work (much of which probably later appeared in the atlas of Mozambique mammals, Smithers & Tello 1976); 167 species of bird based on a list by Hodgson (1971) with supplementary information from Desmond Jackson (1973); 62 reptiles and 35 amphibians from an unpublished list by Don Broadley (but see Broadley & Blake 1973); and 49 freshwater fish compiled by Graham Bell-Cross from museum collections. These lists cover the whole Chimanimani area in both Zimbabwe and Mozambique and cover both montane habitats and lowland forest (effectively the whole TFCA); a list of just montane species would be significantly shorter.

Surprisingly, there are very few endemic or range-restricted vertebrates on the mountains. One amphibian is considered endemic (the Cave Squeaker frog *Arthroleptis troglodytes*, although it has not been found since 1962; ZSL 2016) and one possibly endemic fish, but no endemic bird species.

The Chimanimani Mountains are designated as two Important Bird Areas (IBAs), one on the Zimbabwe side of the border (Childes & Mundy 2001) and a much larger one on the Mozambique side (Parker 2001). Only three restricted-range bird species occur here – Swynnerton's Robin *Swynnertonia swynnertoni*, Chirinda Apalis *Apalis chirindensis* and the Briar Warbler *Prinia robertsii*. Together, these IBAs cover a large part of both the highlands and surrounding lowland forests and include five globally threatened or near-threatened (A1) species – Taita Falcon *Falco fasciinucha* (VU), Swynnerton's Robin (VU), Southern Banded Snake-eagle *Circaetus fasciolatus* (NT), Blue Swallow *Hirundo atrocaerulea* (NT) and Plain-backed Sunbird *Anthreptes reichenowi* (NT). Of these, only the Blue Swallow occurs only in the highland, non-forested habitats. The status of its population on the Mozambique side seems to be uncertain (Parker 2005, Little 2013). However, during our fieldwork there would appear to be as much suitable habitat on the Mozambique side as on the Zimbabwe.

Despite the large number of endemic plants, some of which appear to be suitable larval food species, there is only one species of butterfly known to be endemic to the Chimanimani Mountains – *Lepidochrysops barnesii* (Lycaenidae) – known only from montane grassland at 1800 m in a small valley on the Zimbabwe side. In addition there are five other near-endemic species known only from montane grasslands or Afromontane forest along the Zimbabwe–Mozambique borderlands. Surprisingly there is no checklist of Lepidoptera from the mountains (Alan Gardiner and Colin Congdon, both pers. comm. October 2016).

View over upper Mufomodzi valley from slopes of Mt Binga, northern Chimanimani [TS].

5. VEGETATION

5.1 Regional Level

At a continental level, the vegetation of the Chimanimani Mountains and associated mountains along the Zimbabwe–Mozambique border has been described as Undifferentiated Afromontane Vegetation (unit 19a) by White in his map of African vegetation (White 1983). Forming part of his Afromontane archipelago-like regional centre of endemism, this type is embedded within the Zambezian regional centre of endemism comprising woodlands and other formations on the main continental plateau. The Afromontane archipelago extends from Yemen through the Ethiopian Highlands, the Albertine Rift and Malawi to the Drakensberg and Cape mountains in South Africa, with outliers in West Africa and on the Angolan scarp. In his earlier study on the Afromontane Region, White (1978) recognised the Chimanimani area as an 'island' in this Afromontane archipelago. Following Hedberg's work on vegetation zonation on East African mountains (Hedberg 1951), in which he describes a Montane Forest belt, an Ericaceous Belt and an Afro-alpine Belt, White (1978) mentions the presence of an Ericaceous zone at higher altitudes on the Chimanimanis and on Mt Malawi (although the Nyanga massif should certainly also be included here). However, zonation on the mountains of south-central Africa is not as marked as on the taller East African mountains such as Mt Kenya, Mt Kilimanjaro and the Ruwenzori. White suggests that the Ericaceous Belt, which in the case of the Chimanimani and other similar mountains is the formation that supports most of the narrow-range species, is best described together with the Montane Forest Belt, while the Afro-alpine Belt is more distinctive (but see Section 4.4).

At a regional level, the main framework available is that for the whole Flora Zambesiaca area (Wild & Barbosa 1968), which describes all the montane vegetation in this area as *Themeda–Exotheca–Loudetia* Submontane and Montane Grassland (unit 68). In his precursor study of the vegetation of Mozambique, Barbosa (1955) shows the upland Chimanimani area as Zona subalpestre (complexo 39), which he divides into eight subtypes, including evergreen forest with *Podocarpus*, secondary "matagais" with *Widdringtonia*, *Phillipia* (now *Erica*) and sometimes *Brachystegia spiciformis*, stands of *Strelitzia*, scrub with species of *Erica*, *Passerina*, *Helichrysum* and *Aeschynomene*, secondary grasslands, and, finally, boggy areas with *Sphagnum*, *Lycopodium* and *Drosera*.

5.2 District Level

At a more local level, and with the exception of moist forest, the vegetation of the Chimanimani Mountains is primarily determined by and follows the underlying geology (Phipps & Goodier 1962, Goodier & Phipps 1962, Wild 1964). Altitude is also a factor with sclerophyllous vegetation and grasslands at higher altitudes and woodland and forests lower down. There are distinct differences within these vegetation formations depending on substrate.

An idea of the "greenness" of the vegetation across the mountains is given in Figure 5.1, a recent (2013) satellite image that was used in a biomass assessment study (Casey Ryan, pers. comm.). The quartzite areas show up clearly as having significantly less vegetation reflectance.

By far the most comprehensive account of the vegetation and ecology of the Chimanimani Mountains, although confined primarily to the Zimbabwe side, is found in Phipps & Goodier's 1962 Journal of Ecology paper, with a map and less detailed account in Goodier & Phipps (1962). Their accounts are simplified and paraphrased below along with some additional observations, particularly for the Mozambique side which they did not look at in detail, and their map is shown in Figure 5.2. The area covered is essentially above 1000 m altitude.

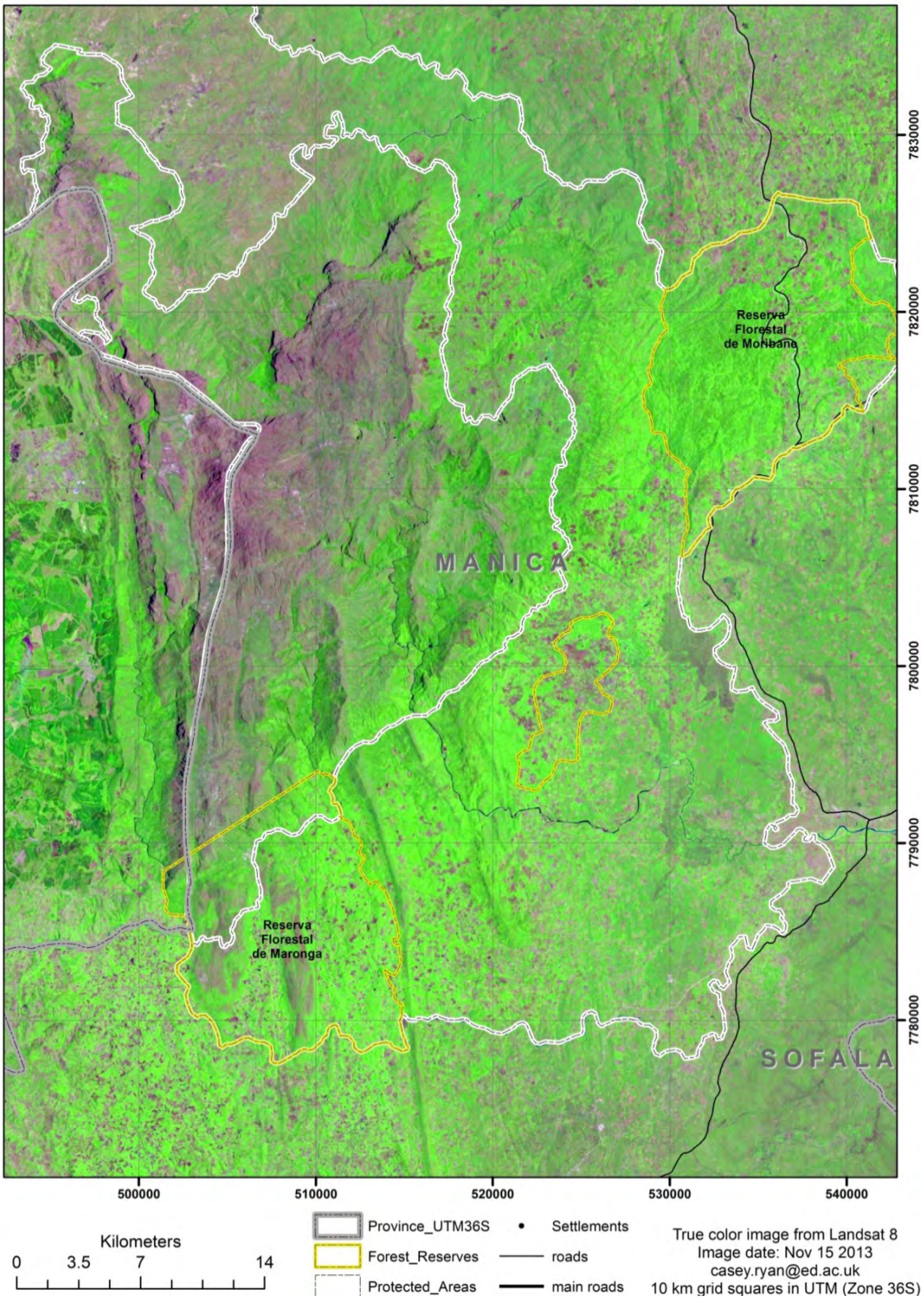


Figure 5.1. Satellite image of the Chimanimani TFCA area showing levels of vegetation production (source: Casey Ryan, pers. comm.).

The main vegetation types recorded by Goodier & Phipps (1962) were:

A. Forest
  i) Dry montane forest
  ii) Marginal (seral) forest

B. Woodland
  i) *Uapaca kirkiana* woodland (miombo)
  ii) *Brachystegia spiciformis* woodland (miombo)
  iii) *Brachystegia tamarindoides* woodland

C. Scrub
- i) Ericaceous scrub
- ii) Proteaceous scrub

D. Grassland (both wet and well-drained)
- i) On quartzite terraces
- ii) On schist slopes
- iii) Hydromorphic grasslands

E. Aquatic communities

F. Lithophytic communities

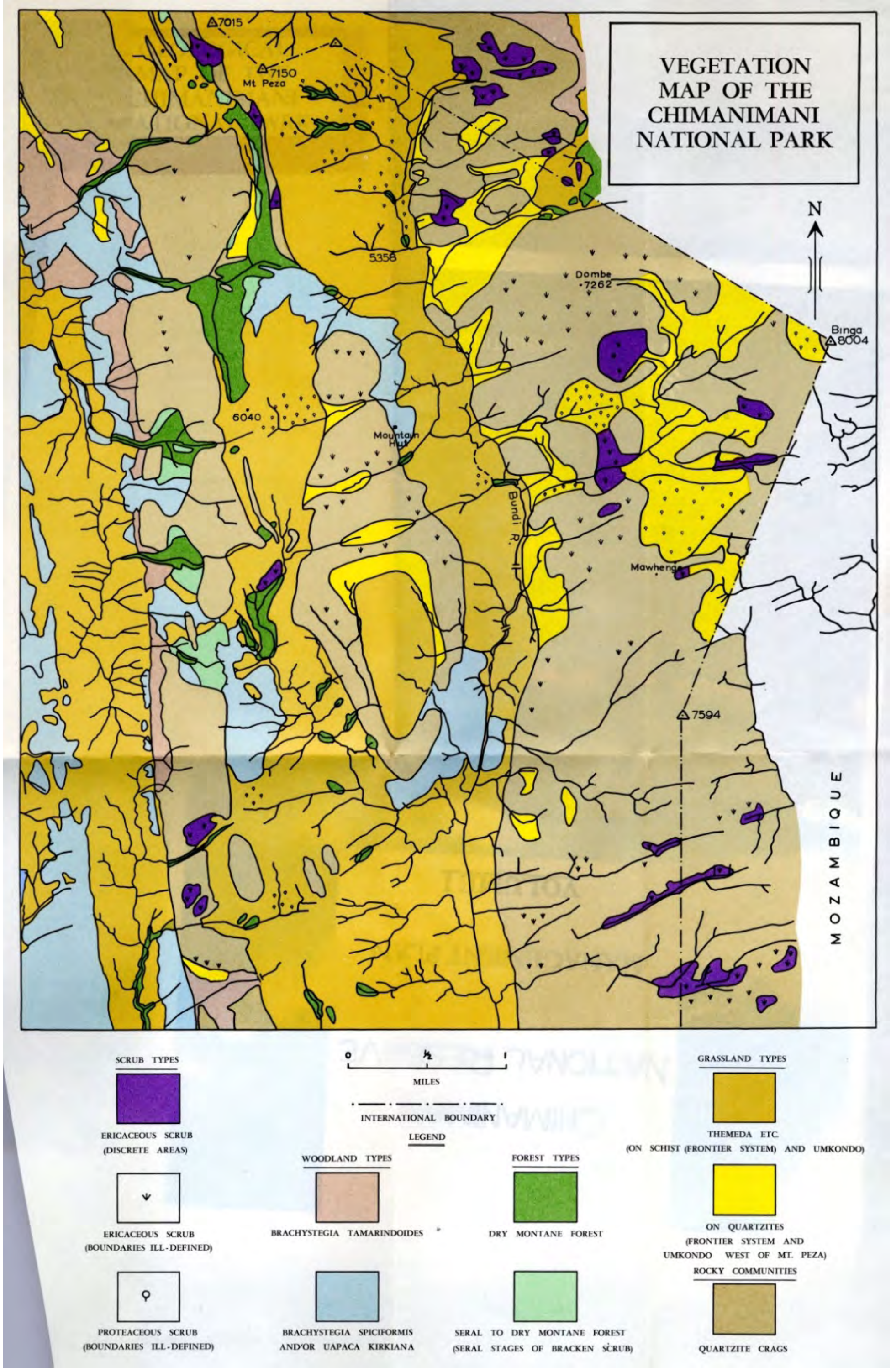


Figure 5.2. Vegetation map of the Zimbabwe portion of the Chimanimani Mountains (from Goodier & Phipps 1962).

A. Forest

The forests found above 1000 m are somewhat dry but with a 10–15 m high closed canopy and a sparse ground flora (type A.i). Few trees are larger than 30 cm diameter, while lianas and epiphytes are common in the canopy with ferns and mosses in the ground layer. This is often called Afromontane forest and is somewhat stunted compared to forests at lower altitudes. It mostly occurs in smaller patches from 1 to 5 ha in extent, although in favourable localities they can reach 30 ha. The largest patch seen, on the west-facing slopes above the Rio Nyahedzi, was around 240 ha (Figure 5.3). Most patches are confined to sheltered gullies (sometimes called kloofs) that are subject to less evapotranspiration. There does not appear to be a direct link to underlying geology, possibly as once forest develops it creates its own humus-rich soil. Access to year-round moisture and better protection from wild fires is also important, although fire itself is not thought to be a major determinant of these forest's distribution (Müller 1999). Some of the more characteristic trees are *Schefflera umbellifera*, *Ilex mitis*, *Macaranga mellifera*, *Maesa lanceolata*, *Morella pilulifera*, *Podocarpus milanjianus* and *Syzygium cordatum*. In drier areas *Widdringtonia nodiflora* can be found.

Surrounding many forest patches and in smaller gullies, a scrubbier vegetation type can be found (type A.ii), transitional between Ericaceous scrub and forest. Common species here include *Erica* (*Phillipia*) *mannii*, *Englerophytum magalismontanum*, *Rapanea melanophloeos* and *Myrsine africana*, while bracken (*Pteridium aquilinum*) is found on the outer margins where soils are somewhat deeper and with some humus. Along some sheltered rocky streams groves of the banana-like *Strelitzia caudata* are often seen, while the tree fern *Cyathea capensis* grows from sheltered stream banks in more open areas.

Figure 5.3. Afromontane forest on slopes of Mt Nhamadimo [JT].

Figure 5.4. *Brachystegia tamarindoides* woodland on quartzite [JT].

B. Woodland

Woodland is of three types, all generally termed miombo, with their distribution primarily related to underlying geology and soil type. Confined mostly to well-drained slopes, woodland is most extensive at medium to lower altitudes and only occasionally found above 1400 m. Using Google Earth Pro the extent of denser woodland (all types) above approximately 1000 m altitude was estimated at 112 km^2. Most woodlands are fairly open with about 20–60% canopy cover and trees usually only 4–8 m high. Trees are shorter at higher altitudes and on more shallow soils, as well as being much more open in their canopy.

Uapaca kirkiana (mzhenje) woodland (type B.i) is mostly confined to altitudes below 1200 m covering much of the lower eastern slopes and is rarely found on quartzite. At lower altitudes it is typically found with *Brachystegia utilis*, *Pterocarpus angolensis* and *Pericopsis angolensis* and forms a typical and extensive miombo woodland, while at higher altitudes these other species tend to disappear. The ground flora, especially higher up, tends to be sparse, commonly with *Loudetia simplex* and *Helichrysum kraussii*. In some places closer to streams, the stilt-rooted *Uapaca lissopyrena* is seen, which can also form a localised woodland.

Brachystegia spiciformis (msasa) woodland (type B.ii) is primarily found on schist soils and rarely on quartzite. Trees can be quite low (2–4 m high) and scattered at higher elevations, although large spreading trees can be seen in favourable sites. This type is generally found at lower altitudes with *Uapaca kirkiana* and sometimes *Faurea saligna*, with medium-height grasses 60–90 cm high of *Themeda triandra*, *Digitaria* species, *Loudetia simplex* and *Tristachya nodiglumis*, sometimes with *Pteridium aquilinum* and the creeper *Smilax anceps*.

Brachystegia tamarindoides subsp. *microphylla* woodland (type B.iii, Figure 5.4) is very attractive and confined to quartzite outcrops and rocky areas where the low spreading branches are often draped in long strands of *Usnea* lichen. The canopy is very open but, owing to the generally rocky or shallow substrate, there is a sparse herbaceous layer. Although Phipps & Goodier (1962) said it has a lower altitudinal limit than the other two woodland types, we did not find that to be the case in the Mozambique side.

C. Scrub

This group of vegetation types is widespread across the plateau above about 1200 m altitude; Phipps & Goodier (1962) recognised five shrubland types with various facies, but we only cover the two main ones here.

Ericaceous scrub (type C.i) is one of the more species-rich vegetation types across the mountains and it is in this that many of the Chimanimani endemics or near-endemics are found. It is characterised by low (0.5–1 m to 3 m high) shrubs of *Erica* (*Phillipia*) *simii* along streamsides, *Erica pleiotricha*, *E. johnstonii* and *E. lanceolifera* in semi-fire protected areas and, especially, taller shrubs of *Erica* (*Phillipia*) *hexandra* on rocky outcrops. All of these species are only known from quartzite substrates. Along stream margins Ericaceous scrub can give way to marginal evergreen forest with *Podocarpus milanjianus*, *Widdringtonia nodiflora* and *Syzygium cordatum* (type A.i), sometimes with *Strelitzia caudata*. The *Erica hexandra* thickets, forming ‘rock gardens’ or on boulder slopes, are fairly widely distributed above 1400 m, and are often associated with *Schistostephium oxylobum*, *Anthospermum vallicola*, *Myrsine africana*, *Phylica ericoides*, *Passerina montana* and *Aloe munchii*, along with some shrubby legumes (Figures 5.5, 5.6). This formation is said to be fire-sensitive (Phipps & Goodier 1962), although it can readily regenerate. In addition, fires are stopped from spreading rapidly by the large gaps between boulders, which fires do not readily jump across.

Figure 5.5. Rock garden, N Chimanimani [JT].

Figure 5.6. Rock garden, N Chimanimani [JT].

The other main scrub type is Proteaceous scrub (type C.ii), primarily found on rolling schist grassland between 1100 and 1800 m, although it is not always easy to clearly demarcate this type and schist grassland. It is characterised by low (1 to 2 m high) shrubs of *Protea caffra* (previously *P. gazensis*), *P. welwitschii*, *P. wentzeliana* (previously *P. crinita*) and *Leucospermum saxosum*, along with the small shrublet or suffrutex *Morella chimanimaniana*. Associated species, especially at slightly lower altitudes, are *Parinari curatellifolia*, *Faurea saligna* and *Syzygium cordatum*, all of which can become small trees. Woody herbs include *Aeschynomene grandstipulata* and *Diplolophium buchananii*. Unlike ericaceous scrub, this vegetation type is moderately fire-tolerant and many stems are blackened at the base.

Two of the three other scrub types described by Phipps & Goodier (1962) were noted, but we prefer to group them under the two main types.

Mixed sclerophyll scrub seems to be intermediate between the two previous types, restricted as they are to differing substrates. There are a number of places where quartzite-rich soils have slumped over red schistose soils, creating a sort of hybrid environment. In our fieldwork we did not recognise this intermediate type, regarding all scrub on rocky quartzite terrain as ericaceous scrub or 'rock gardens'.

Bracken scrub, vegetation dominated by the bracken fern *Pteridium aquilinum*, is quite clearly discernible in the field but seems to normally occur on slightly deeper, well-drained and humus-rich soils associated with forest patches. Associated species, depending on the proximity to forest patches, include *Aeschynomene gazensis*, *Anthospermum vallicola*, *Buddleja salviifolia*, *Dissotis princeps*, *Eriosema montanum*, *Kotschya thymodora*, *Harungana madagascariensis*, *Hypericum roeperianum*, *Polygala virgata* and *Tetradenia riparia*, along with the thorny scrambler *Smilax anceps*. The grasses are often quite tall and include *Themeda triandra*, *Eragrostis* species and even *Hyparrhenia newtonii*. As Phipps & Goodier point out, this is essentially a seral or intermediate type, and if there was no fire it may well thicken up to a woody scrub or even forest.

We did not specifically note any *Thesium* sclerophyll scrub, as described by Phipps & Goodier, on the Mozambique side. It is said to be limited in extent on the Zimbabwe side on quartzite and is dominated by the semi-parasitic *Thesium whyteanum*.

D. Grassland

This is the most extensive and characteristic vegetation formation across the plateau and is also moderately species-rich. Generally found on level or rolling terrain, grassland is rarely seen on steeper rocky slopes except as small pockets on more level terraces. Although Phipps and Goodier say this is a fire sub-climax type, we suggest that it is as much a natural response to prevailing soil and climatic conditions (as discussed in Section 6.5), although its extent may have increased with the coming of humans while boundaries between grassland and forest or scrub have become harder and more marked.

There are three broad grassland types based on soil type and drainage status, with the most abundant grass – *Loudetia simplex* – being generally dominant in the non-hydromorphic types.

Grasslands on shallow soils derived from quartzite or quartzitic sandstone (type D.i) are mostly associated with larger broad valleys of larger rivers such as the Bundi and Mufomodzi. Grasses are fairly low in height and somewhat tufted. Apart from the dominant *Loudetia simplex*, *Sporobolus festivus*, *Panicum brazzavillense*, *Elionurus muticus*, *Monocymbium ceresiiforme*, *Panicum ecklonii*, *Rhytachne rottboellioides* and *Trachypogon spicatus* are typical. In wetter patches *Eriospermum mackenii*, *Otiophora inyangana*, *Mesanthemum africanum*, *Xyris* spp. and *Platycaulos* (*Restio*) *quartziticola* are seen. A figure for its extent (separate from quartzite scrub and bare rock) is not available, but is probably in the order of 50–100 km^2.

The other main grassland type is found on rolling hills of red soils derived from schist (type D.ii). This occurs across the Chimanimani massif but large expanses are seen in the Bundi valley and on Mt Peza in Zimbabwe, and in Mozambique in the middle reaches of the Rio Murera (Ma-Esese) and the eastern portion flanking the middle reaches of the Rio Mufomodzi (Figure 5.7). The grasses are mostly denser and taller than on the shallow and nutrient-deficient quartzite soils. Although *Loudetia simplex* is common, the most characteristic grass is *Themeda triandra*, along with *Tristachya hispida*, *Monocymbium ceresiiforme* and the sedge *Bulbostylis contexta*. Small shrubs of *Protea gazensis*, *Indigofera cecilii* and the schist endemic *Morella chimanimaniana* are also typical, as is bracken *Pteridium aquilinum*. Another characteristic feature, absent from quartzite grassland, are low (50 cm high) rounded termite mounds (Figure 5.8) as well as aardvark holes. These grasslands are readily discernible on Google Earth imagery, from which an estimated total extent of 150 km^2 was calculated.

Figure 5.7. Schist grassland, C Chimanimani [JT].

Figure 5.8. Termite mound in schist grassland, C Chimanimani [JT].

Hydromorphic grassland (type D.iii), the last of the three broad types, is, as the name suggests, associated with lower parts of the soil catena near watercourses, areas of impeded drainage and around seepages. Soils can be quite peat-rich. Phipps & Goodier separate out those on quartzite and schist, and provide detailed and differentiated species lists, but here they are combined. The habitats can be more open than in the better-drained grasslands, so a number of less-competitive and low-growing herbs such as *Xyris* species, *Mesanthemum africanum* and various orchids are found, as well as sedges such as *Cyperus denudatus*.

E. Aquatic communities

These are obviously very restricted in extent. Very few submerged plants such as *Isolepis fluitans* have been seen, but others are associated with sand banks and stream banks that are regularly flooded. At lower altitudes, below 900 m, submerged species such as *Hydrostachys polymorpha* are found, with the palm *Phoenix reclinata* and screw pine *Pandanus livingstonianus* along the river banks.

F. Lithophytic communities

The last vegetation type described here is that found growing on exposed rocks – lithophytic – nearly all of which is on quartzite (Figure 5.9). A number of crustose lichens cover the rock but also larger plants such as the tufted sedge *Coleochloa setifera*, *Xerophyta argentea* and *Aloe hazeliana*. Where there are cracks and crevices, woody plants such as *Olea chimanimani* are found along with *Asparagus chimanimaniensis* and *Plectranthus chimanimaniensis*. In shaded crevices *Impatiens salpinx* (also on shaded streambanks), various *Streptocarpus* species and a number of small ferns are found. Small lithophytic orchids such as *Polystachya valentina* can be locally common.

The relationship between vegetation type, geology and soils was described in detail by Phipps & Goodier (1962). A modified version of their table showing these relationships, and that with fire, is given in Table 5.1.

Figure 5.9. Quartzite crags, N Chimanimani [JT].

Chimanimani grassland [JT]

Table 5.1. Summarized relationships of Chimanimani plant communities and ecological factors (modified from Phipps & Goodier 1962).

Ecological factors	Level ground/ deeper soil	Medium slope/ shallower soil	Rocky slopes, crags	Schist soils	Quartzite soils	Permanently high water table soils	Seasonally high water table soils	Moist but well-drained soils	Severe fires	Moderately hot fires	Fires rare	Fires occasional	Aquatic	Wind-exposed areas	Sheltered areas	Below 1500 m	1350-1650 m	Above 1650 m
A. FOREST																		
Ai) Dry montane forest	×	×		×	×			×			×				×	×	×	
Aii) Marginal (seral) forest	×	×	×	×	×			×				×			×	×		
B. WOODLAND																		
Bi) *Uapaca kirkiana* woodland		×		×	×		×			×				×		×	×	
Bii) *Brachystegia spiciformis* woodland		×		×			×			×				×		×	×	
Biii) *Br. tamarindoides* woodland		×			×		×			×				×		×	×	
C. SCRUB																		
Ci) Ericaceous scrub			×		×			×			×	×		×	×		×	×
Cii) Proteaceous scrub	×	×		×	×		×			×		×		×			×	×
D. GRASSLAND																		
Di) On quartzite terraces	×				×		×		×	×				×		×	×	
Dii) On schist slopes	×			×			×		×					×		×	×	
Diii) Hydromorphic grasslands	×			×	×	×			×					×			×	
E. AQUATIC COMMUNITIES													×			×	×	
F. LITHOPHYTIC COMMUNITIES			×		×							×		×	×	×	×	×

6. BOTANY AND ECOLOGY

The main botanical and ecological findings of the study are described below. This is followed by conservation assessments carried out under the project. A more detailed account of the threats is given in the following chapter (Sections 7.1 to 7.4).

6.1 Species and Collections

Three fieldtrips were undertaken under the project, two in 2014 (April and October-November) and one in 2016 (April-May). The total time spent up in the mountains was 37 days and a fairly extensive area was covered, particularly across the centre and northern parts. The main places visited are shown on a Google Earth image (Figure 6.3).

The range of fieldwork conducted included general botanical survey and collecting, which was mostly focussed on species of restricted distribution, and a survey of plant habitats and their associated threats. To help with the field surveys, an informal illustrated field guide for these species was compiled at Kew (Hadj-Hammou 2014).

There were 11 collectors with numbered series at different times, with an overall total of 927 numbered collections (346 in Apr 2014, 183 in Oct-Nov 2014 and 398 in Apr-May 2016). All specimens, where possible, were collected in series of three or four, with the top duplicate going to the National Herbarium in Maputo (LMA) and duplicates to Kew in London (K), the National Herbarium in Harare (SRGH), and in many instances also to the Meise Herbarium in Belgium (BR) and the Micaia herbarium at Ndzou camp. Duplicates of N. Brummitt numbers (mostly Pteridophytes) went to the Natural History Museum in London (BM).

Figure 6.1. Plant drier in camp [JT].

Figure 6.2. Plant collecting [JT].

Provisional identifications, at least to genus, were made of all plant specimens collected in the field, aided by the illustrated field guide mentioned above (Hadj-Hammou 2014). Identifications were confirmed or re-determined at Kew by a range of plant family specialists and African plant generalists through reference to relevant literature (notably Flora Zambesiaca), online resources such as the Flora of Zimbabwe and Flora of Mozambique websites (http://www.mozambiqueflora.com and http://www.zimbabweflora.co.zw) and comparison with authoritatively named collections in the Kew herbarium. All specimens collected were databased in a BRAHMS database (Filer 2016), with a record of collector(s), collecting number, date, locality including georeference, habitat notes, plant description, frequency and identification.

In addition to the field collections, data on specimens of restricted distribution held at the Kew and Harare herbaria and all records from available literature were collated in the same Brahms database (see Section 4.3). The locality for each collection was georeferenced wherever possible, but as many old specimen records state only "Chimanimani Mountains" for the locality and so are not sufficiently precise for accurate georeferencing. This added 1426 records of the priority plant species. Together with the field observations, this database was used as a basis for species conservation assessments.

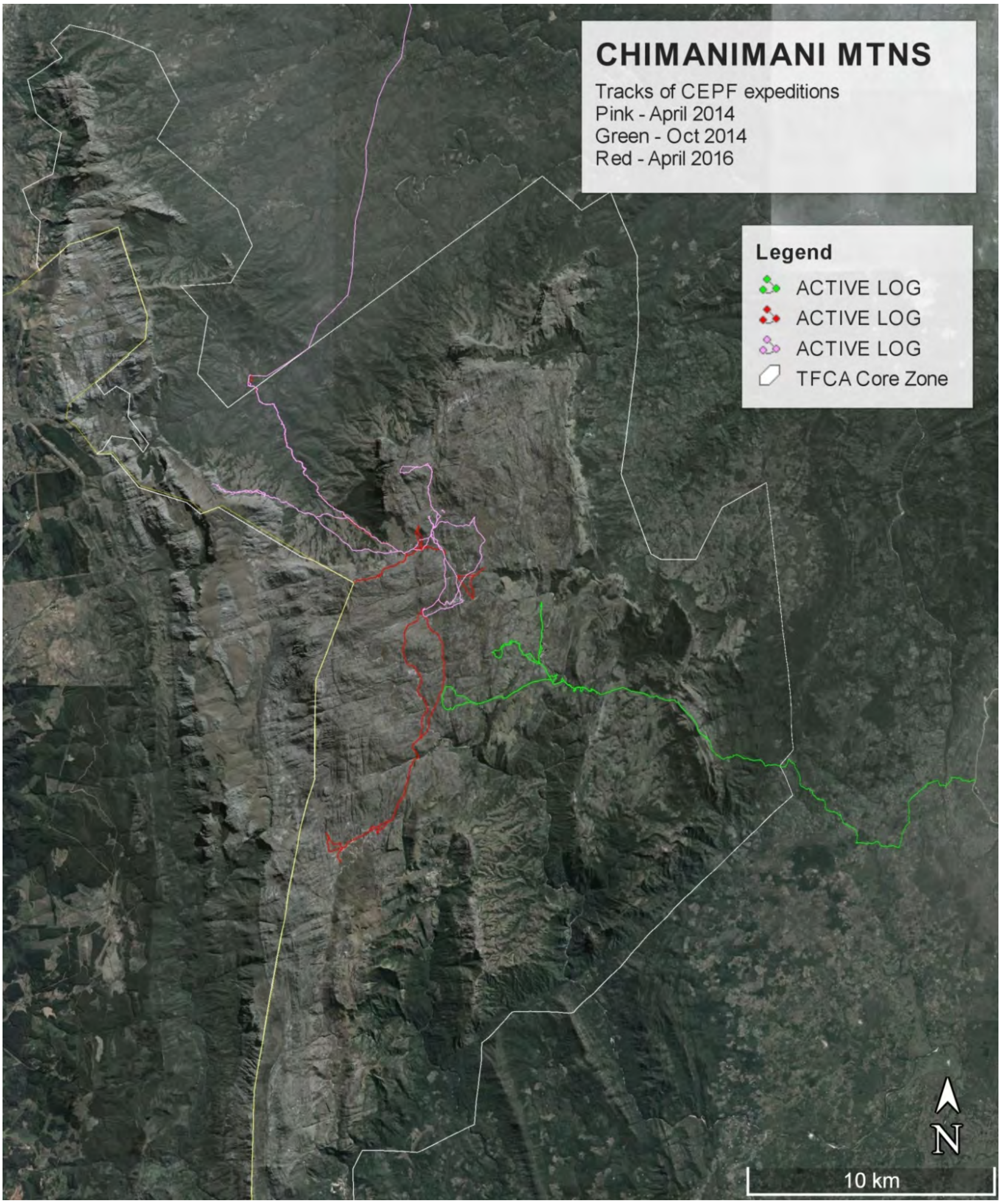


Figure 6.3. Main tracks across the Chimanimani mountains taken during the CEPF expeditions in 2014 & 2016 (Google Earth image). The international boundary is shown in yellow and the TFCA Core Zone boundary in white.

6.2 New Species and Records

The three field expeditions to the high massif, together with fieldwork in the forested lowlands for the associated Darwin Initiative project (Timberlake *et al.* 2016), have generated a wealth of data on the flora of this mountain range. During the two 2014 field expeditions, a total of 24 vascular plant species were newly recorded for Mozambique (Table 6.1), of which nine are strict Chimanimani endemics previously only known from the Zimbabwe side. This reflects the previous under-exploration of the Mozambique side and helps confirm that the Chimanimani endemics are widespread across the massif in favourable habitats (see Section 6.3).

Table 6.1. Species newly recorded for Mozambique during the 2014 and 2016 Chimanimani botanical expeditions.

Family	**Species**	**Distribution**
Apocynaceae	Sisyranthus rhodesicus *Weim.*	Chimanimani & Nyanga only
Asparagaceae	Eriospermum mackenii Hook.f. subsp. phippsii (Wild) P.C.Perry	Chimanimani endemic
Commelinaceae	Commelina pycnospatha *Brenan*	D.R. Congo, Zambia, Tanzania
Cyperaceae	Costularia natalensis *C.B.Clarke*	Malawi, Swaziland, E South Africa
Iridaceae	Hesperantha ballii *Wild*	Chimanimani endemic
Leg: Papilionoideae	Tephrosia chimanimaniana *Brummitt*	Chimanimani near-endemic
Leg: Papilionoideae	Pearsonia mesopontica *Polhill*	Chimanimani near-endemic
Loranthaceae	Helixanthera woodii *(Schltr. & K.Krause) Danser*	Chimanimani, South Africa (KwaZulu-Natal)
Orchidaceae	Cynorkis debilis *(Hook.f.) Summerh.* (= C. hanningtonii *Rolfe*)	Angola to Tanzania, Malawi, Zambia and Zimbabwe
Orchidaceae	Polystachya valentina *La Croix & P.J.Cribb*	Manica Highlands endemic
Peraceae	Clutia sessilifolia *Radcl.-Sm.*	Chimanimani endemic
Poaceae	Danthoniopsis pruinosa *C.E.Hubb.*	Tanzania to South Africa
Poaceae	Eragrostis desolata *Launert*	Chimanimani endemic
Poaceae	Melinis kallimorpha *(Clayton) Zizka*	Kenya to Namibia & Botswana
Poaceae	Panicum eickii *Mez*	D.R. Congo to Kenya, S to Zimbabwe
Podocarpaceae	Podocarpus elongatus *(Aiton) Pers.*	Chimanimani, South Africa (Cape); see discussion
Polygalaceae	Polygala spicata *Chodat*	C.A.R. & Kenya, S to Angola & Zimbabwe
Rubiaceae	Mitrasacmopsis quadrivalvis *Jovet*	D.R. Congo to Tanzania, S to Angola & Zambia, Madagascar; notable range extension
Santalaceae	Thesium chimanimaniense *Brenan*	Chimanimani endemic
Santalaceae	Thesium dolichomeres *Brenan*	Chimanimani endemic
Santalaceae	Thesium pygmaeum *Hilliard*	Chimanimani endemic
Scrophulariaceae	Teedia lucida *(Sol.) Rudolphi*	Chimanimani, Swaziland, Lesotho, widespread in South Africa
Thymelaeaceae	Struthiola montana *B.Peterson*	Chimanimani endemic; second ever record
Xyridaceae	Xyris asterotricha *Lock*	Chimanimani endemic

Of the other range extensions into Mozambique, most are of widespread species for which the Mozambique record is not unexpected and/or has already been recorded from the Zimbabwe side of the massif. However, three species are worthy of note:

Mitrasacmopsis quadrivalvis – a widespread though local herb of miombo woodland of eastern and south-central Africa for which the new record from Chimanimani (*Ballings & Wursten* 2218, 1352 m in rocky *Brachystegia* woodland) represents a significant range extension in continental Africa, although it has previously been recorded from Madagascar.

Its absence from large areas of miombo woodland in south-eastern tropical Africa is difficult to explain.

Helixanthera woodii – a small parasitic shrub on trees, this was previously only known from the Zimbabwe side of Chimanimani and from lowland and coastal forests in KwaZulu-Natal. Our new records from Mozambique were from mid-altitude forest margins (1200–1350 m; *Ballings & Wursten* 2220, *Mapaura* 639) and riverine vegetation. The species requires further investigation to confirm that the Chimanimani plants are conspecific with those from South Africa.

Podocarpus elongatus (Figure 6.4) – two *Podocarpus* species are present in Chimanimani – the large-leaved *P. milanjianus*, usually a medium to large tree, and a small-leaved shrub or treelet named as *P. elongatus* by Aljos Farjon (Farjon 2010, Farjon & Filer 2013, and on Kew herbarium sheets). The latter species had previously been recorded only from the Zimbabwe side of Chimanimani but was found to be locally frequent in gullies and rocky river bottoms both on the high plateau and at lower elevations in the forest zone in the south. However, *P. elongatus*, a shrub or treelet with small, narrow and markedly acute leaves, is known mostly from the Cape region of South Africa. Although the Chimanimani taxon appears remarkably similar to 'true' *P. elongatus* in habit and leaf form, the geographical distribution is highly irregular. It is possible that the Chimanimani plants represent a distinct, cryptic species, but this would require molecular analyses to confirm. The genus is in need of revision in Africa. At present it is best to consider these plants as conspecific with *P. elongatus*.


Figure 6.4. *Podocarpus elongatus* [JO].

Nine species were collected that have either not been matched to any existing species or match previously collected material that has not been fully identified and are outlined below. They may represent new species to science but require more material and/or further study and formal publication.

Ceropegia sp. nov. near *C. linearis* (Apocynaceae) – a small twining herb with a fleshy rootstock found in rocky montane grassland or rock crevices that has only occasionally been seen (*Ceropegia* sp. no. 1 of the Flora of Zimbabwe website; *Ballings & Wursten* 143, *Grosvenor* 395, *Kelly* 94, *Osborne* 1190).

Cyanotis sp. 1 (*Timberlake* 5982) and *Cyanotis* sp. 2 (*Mapaura* 681) (Commelinaceae) – these two species were identified as not matching any known species by Commelinaceae specialist Robert Faden. An account of the genus is currently in preparation for *Flora Zambesiaca* which should help elucidate their status. Several *Cyanotis* collections made on the 2016 expedition may provide extra material.

Empogona sp. nov. near *E. ruandensis* (Rubiaceae) – previously known from two specimens from the Zimbabwe side of the massif (*Müller* 728, *Swynnerton* 4026), it was found in open flower for the first time in October 2014 (*Wursten* 1070) and was also collected in 2016. It was noted as an odd form of *Tricalysia congesta* subsp. *chasei* in *Flora Zambesiaca* (vol. 5 part 3, 2003), but the flowering material reveals further differences. *T. congesta* has since been transferred to *Empogona ruandensis*, but we consider both subsp. *chasei* and the Chimanimani taxon to be distinct from that species.

Indigofera sp. nov. near *I. chimanimaniensis* (Leguminosae: Papilionoideae) – this species has been collected just twice on the Mozambique side (*Hadj-Hammou* 55, *Massunde* 258). It forms part of a group with a number of range-restricted montane species. *I. chimanimaniensis* itself is a Chimanimani near-endemic.

Olinia sp. nov. near *O. vanguerioides* (Penaeaceae) – this species was previously known from three collections (*Whellan* 2203, *Wild* 3606, *Linder* 3990) from the Chimanimanis. It was found on the April 2014 expedition (*Matimele* 2082, 2094) and was the subject of further study by Toral Shah in 2016 when it was found to be scarce. At the time the *Flora Zambesiaca* treatment was being written (1978) only the Wild specimen had been seen and it was recorded as possibly a small-leaved variant of *O. vanguerioides*. Work is ongoing to determine if it should be recognised as a new species or only a new subspecies, but the combination of small leaves and unusual galled flowers (a useful character in this genus) suggests that it is a distinct species.

Streptocarpus sp. nov. near *S. grandis* (Gesneriaceae) – *S. grandis* subsp. *septentrionalis*, an endemic subspecies to Chimanimani, was collected during the April 2014 expeditions along with a second, clearly distinct species close to *S. grandis* but differing in indumentum and flower shape (*Ballings & Wursten* 2246, *Hadj-Hammou* 35). The material is sufficient for description, but the relationship of both this taxon and subsp. *septentrionalis* to *S. grandis* subsp. *grandis* from South Africa requires further investigation. This species was not found in 2016.

Syncolostemon sp. nov. near *S. teucrifolius* (Lamiaceae) – this is known from a single flowering collection from November 2014 (*Mapaura* 727) which appears to be distinct from *S. teucrifolius* in leaf shape and in having very long stamens. More material is needed but it was not found in April–May 2016, probably due to seasonality.

Xyris sp. ?nov. (Xyridaceae) – a single specimen collected in April 2014 (*Hadj-Hammou* 59) at a gold mining site on the Rio Chimuourachetea. It was identified by Mike Lock (a Xyridaceae specialist) who noted that it could not be keyed out in *Flora Zambesiaca* and is possibly new to science, but more material is needed. Several collections of *Xyris* were made in the 2016 expedition and these await identification; they may provide more material.

Research into these potentially new species is ongoing. It is not surprising that new discoveries continue to be made at this botanically-rich site in view of the high levels of endemism and the fact that large areas of the massif on the Mozambique side were largely unexplored prior to this project.

6.3 Endemics

A recent compiled checklist for the Chimanimani mountains above 1200 m altitude lists 923 species and subspecies as being found there (Wursten, Timberlake & Darbyshire, in prep.). Many of these, of course, are also found in other montane areas of central Mozambique and eastern Zimbabwe, and some of them are even restricted to these mountains – the Manica Highlands endemics.

Of greater interest for plant conservation, and arguably of greater importance for conservation managers, are taxa (both species and subspecies) that are found only in the Chimanimani area – the Chimanimani endemics. Excluding the two strictly moist forest species, there are 78 of these (Table 6.4). They can usefully be divided into three groups – those that are confined to lower altitude, often forested areas at the base of the mountains (mostly 200–600 m altitude); those that are confined to Chimanimani District and immediately adjacent districts, yet are not found on the mountains themselves but primarily on Umkondo sandstones (and are not included in Table 6.4); and finally those (by far the greater portion) that are confined to the quartzite and schist areas of the Chimanimani mountains themselves, mostly above 1000 m altitude. These three groups are discussed below.

A complete list of endemics and near-endemic taxa from the Chimanimani mountains and adjacent areas is given in Annex 2.

Low-altitude Endemics

There appear to be eight low or mid-altitude endemics (Table 6.2). Most of these are discussed in more detail in the report on Kew's Chimanimani Darwin project (Timberlake *et al.* 2016). *Vepris drummondii* is a shrub associated with rivers in lowland forest areas and is possibly only near-endemic, while *Synsepalum* sp. near *S. kaessneri* is probably a new species restricted to the Chimanimani forests. *Streptocarpus acicularis* is only known from forested areas at the southern end of the mountains, while the climbing fig *Ficus muelleriana* (Burrows & Burrows 2003: 123) and the perennial herb *Otiophora lanceolata* are found in similar areas but on quartzite, typically within *Brachystegia tamarindoides* subsp. *microphylla* woodland. The wetland herb previously known as *Lindernia flava* is believed to be a new species of *Crepidorhopalon*, but is not confined to quartzite soils, and may not even be endemic to this area. Additional taxa are the two varieties of *Aloe ballii*, both only known from 300–600 m altitude but confined to quartzite substrates. As with the montane endemics, the distribution of most of the lower altitude endemics appear to be linked to the presence of quartzite or sandstone rocks.

Table 6.2. Chimanimani endemic and near-endemic species from lower altitudes (below 600 m).

Taxon	**endemism**	**Conservation assessment**
DICOTYLEDONS		
Asteraceae		
Vernonia muelleri *Wild* subsp. muelleri	E	Na
Gesneriaceae		
Streptocarpus acicularis *I.Darbysh.& Massingue*	E	CR B2
Linderniaceae		
Crepidorhopalon near C. whytei (= Lindernia flava)	E	Na
Moraceae		
Ficus muelleriana *C.C.Berg*	E	EN B1+B2
Rubiaceae		
Otiophora lanceolata *Verdc.*	E	VU B1+B2
Rutaceae		
Vepris drummondii *Mendonça*	NE, F	VU B1+B2
Sapotaceae		
Synsepalum sp. near S. kaessneri	E, F	Na
MONOCOTYLEDONS		
Asphodelaceae		
Aloe ballii *Reynolds* var. ballii	E	VU D2
Aloe ballii *Reynolds* var. makurupiniensis *A.Ellert*	E	VU D2

E = endemic; NE = near-endemic; F = forest species; na = not assessed

Umkondo Sandstone Endemics

Another interesting group of seven endemic taxa, first noted in the course of this study, are those associated with soils derived from Umkondo sandstones across both Chimanimani and Chipinge Districts in Zimbabwe but which are not found on the quartzites and schists of the Chimanimani mountains (Table 6.3). Although most are only recorded from Zimbabwe (with two exceptions, *Tephrosia longipes* var. *swynnertonii* and *T. praecana*), most will undoubtedly be found on similar substrates in Mozambique.

Table 6.3. Chimanimani endemic species – Umkondo sandstones (mostly farming areas).

Taxon	**Conservation assessment**
GYMNOSPERMS	
Zamiacaeae	
Encephalartos chimanimaniensis *R.A.Dyer* [1]	EN B1+B2+C1 [2]
DICOTYLEDONS	
Leg: Papilionoideae	
Aeschynomene gazensis *Baker f.*	EN B1+B2
Indigofera chimanimaniensis *Schrire*	EN B2
Kotschya sp. A of FZ	na
Tephrosia longipes *Meisn.* var. swynnertonii *(Baker f.) Brummitt*	na
Tephrosia praecana *Brummitt*	VU B1+B2
Passifloraceae	
Basananthe parvifolia *(Baker f.) W.J.de Wilde*	na

[1] = uncertain, possible near-endemic; [2] = IUCN Cycad Group assessment
na = not assessed

The cycad *Encephalartos chimanimaniensis* was last recorded in Zimbabwe from farms the Chipinge area over 40 years ago, and it is not clear if these populations still exist. Capela (2006) in his account of Mozambique cycads mentions a good population (perhaps 1200 mature individuals), apparently in the Mukurupini area in Chimanimani National Park (which he suggests is actually in Mozambique), and smaller populations in Mozambique close to the border south of the Lucite River towards Espungabera. Some of these populations are undoubtedly on Umkondo sandstone, but it is not clear if the cycad is also found on quartzite hills. The altitude ranges from about 350 m at Mukurupini up to about 1100 m near Mt Selinda.

The majority of the Umkondo sandstone endemics are papilionoid legumes and all those assessed for conservation status were regarded as being under threat (VU or EN), principally owing to the significant changes in habitats and land cover on the commercial farms and forest plantations of this area. As, by definition, these species are not found in the Chimanimani mountains proper, they are not discussed further here.

Montane Endemics

The third and largest group of Chimanimani endemics comprises a further 70 species, subspecies or varieties that are known only from the upper Chimanimani mountains, athough are sometimes found at lower altitudes. These are listed in alphabetical order by family in Table 6.4 (which also includes the endemic lowland taxa, but not those on Umkondo sandstone) along with any IUCN conservation assessment (see Section 6.4). While most of these species are restricted to the high Chimanimani massif, typically over 1000 m altitude, a few of them also extend to lower altitudes to 350 m along river valleys where they occur on outcrops of quartzite, amongst boulders along exposed river channels or in seasonal wetlands over sand. Of particular note in this regard are *Danthoniopsis chimanimaniensis* and *Mesanthemum africanum*.

Nearly all the Chimanimani montane endemics are found either on quartzitic sandstone rocks or on soils derived from them, as was pointed out many years ago by both Phipps and Goodier (1962) and Wild (1964). Only two (*Morella chimanimaniana* (Figure 6.8) and *Syncolostemon oritrephes*) appear to be confined to the more nutrient-rich schistose soils, although sometimes quartzite endemics can be found on what appear to be soils of mixed provenance.

Near-endemics

In addition to the 78 strict Chimanimani endemics (high and lower altitude), there are an additional 21 species that can be considered as near-endemics (Table 6.5, Annex 2), taxa that are found in the mountains but also in some adjacent areas such as the commercial farmland and forestry plantations of Chimanimani and Chipinge Districts in Zimbabwe (including Mt Pene), mountains or upland areas such as Rotanda and Tsetserra in Mozambique, the Banti, Cashel and Himalaya areas in Zimbabwe, and around Chirinda Forest. Species that have also been found further afield, such as on Mt Gorongosa, the Vumba, Stapleford Forest area or Nyanga are here categorised as Manica Highland endemics (see Clark *et al.* in press; Table 6.5). There are thought to be at least 33 of these Manica Highland endemics recorded from the Chimanimani area, but the final figure is likely to be higher.

One species of interest is the very showy and quite common shrub, *Leucospermum saxosum* (Figure 6.5). Originally it was considered to be a Chimanimani endemic, but individuals have since been found in the northern Drakensberg mountains of eastern South Africa (Tzaneen and Pilgrims Rest, Beard 1993: 106). By the definitions used in this report, it is also not even a near-endemic as the disjunction is large (600 km), although out of interest it is included in Annex 2.

A further species of biogeographic interest is *Dianella ensifolia*, which is frequent in the lowland forests in Maronga (*Darbyshire* 877) and at Thekeza, Zomba (*Massunde* 13) but is also recorded at higher altitudes on the eastern slopes of Mt Mandzudzu in open *Brachystegia* woodland at c. 1000 m (*Mapaura* 700). It has a very disjunct distribution, being known mainly from the Indian Ocean fringe; in continental Africa it is restricted to the Chimanimani mountains and Mt Mabu. An attractive shade-loving herb and cultivated as an ornamental, it is almost certainly native here.

Figure 6.5. *Leucospermum saxosum*, with a disjunct distribution [JO].

Figure 6.6. *Plectranthus chimanimaniensis*, a common Manica Highlands endemic [BW].

Table 6.4. List of species endemic to the Chimanimani massif (quartzite and schist) at montane and lower altitudes, along with Red List assessments.

Taxon	**Altitude**	**Moz/Zim**	**Conservation assessment**
DICOTYLEDONS			
Apiaceae			
Centella obtriangularis *Cannon*		M	VU D2
Apocynaceae			
Asclepias graminifolia *(Wild) Goyder*		M Z	LC
Ceropegia sp. nov. near C. linearis [1]		M Z	
Raphionacme chimanimaniana *Venter & R.L.Verh.*		Z	EN B2ab(iii)
Asteraceae			
Anisopappus paucidentatus *Wild*		M Z	LC
Aster chimanimaniensis *Lippert*		M Z	DD
Helichrysum africanum *(S.Moore) Wild*		M Z	LC
Helichrysum maestum *Wild*		Z	
Helichrysum moorei *Staner* (= H. spenceranum *Wild*)		M Z	LC
Senecio aetfatensis *B.Nord.*		M Z	LC
Vernonia muelleri *Wild* subsp. muelleri	B	M Z	
Vernonia nepetifolia *Wild*		M Z	
Balsaminaceae			
Impatiens salpinx *Schulze & Launert*		M Z	VU D2
Campanulaceae			
Lobelia cobaltica *S.Moore*		M Z	LC
Caryophyllaceae			
Dianthus chimanimaniensis *S.S.Hooper*		M	VU D2
Crassulaceae			
Kalanchoe velutina *Britten* subsp. chimanimaniensis *(R.Fern.) R.Fern.*		M Z	
Ericaceae			
Erica wildii *Brenan*		M Z	LC
Euphorbiaceae			
Euphorbia rugosiflora *L.C.Leach*		Z	EN D
Gesneriaceae			
Streptocarpus acicularis *I.Darbysh.& Massingue*	A	M	CR B2
Streptocarpus montis-bingae *Hilliard & B.L.Burtt*		M	DD
Streptocarpus sp. nov. near S. grandis [1]		M	
Lamiaceae			
Aeollanthus viscosus *Ryding*		M Z	LC
Plectranthus caudatus *S.Moore* [2]		M Z	VU D2
Syncolostemon flabellifolius *(S.Moore) A.J.Paton*	B	M Z	LC
Syncolostemon oritrephes *(Wild) D.F.Otieno* [3]		M Z	VU D2
Syncolostemon sp. nov. near S. teucrifolius [1]		M	
Leguminosae: Papilionoideae			
Aeschynomene aphylla *Wild*		M Z	VU D2
Aeschynomene chimanimaniensis *Verdc.*		M Z	LC
Aeschynomene grandistipulata *Harms*		M Z	LC
Crotalaria phylicoides *Wild*		M Z	LC
Indigofera sp. nov. near I. chimanimaniensis [1]		M	
Rhynchosia stipata *Meikle*		M Z	LC

Linderniaceae			
Crepidorhopalon cf. whytei (= Lindernia flava) [4]	A	M Z	
Melastomataceae			
Dissotis pulchra *A.& R.Fern.*		M Z	VU D2
Dissotis swynnertonii *(Baker f.) A.& R.Fern.*		M Z	VU D2
Moraceae			
Ficus muelleriana *C.C.Berg*	A	M	EN B1+B2
Myricaceae			
Morella chimanimaniana *Verdc.& Polhill* [3]		M Z	
Oleaceae			
Olea chimanimani *Kupicha*		M Z	LC
Orobanchaceae			
Buchnera subglabra *Philcox*		M Z	VU D2
Penaeaceae			
Olinia sp. nov. near O. vanguerioides [1]		M Z	
Peraceae			
Clutia punctata *Wild*		Z	LC
Clutia sessilifolia *Radcl.-Sm.*		M Z	LC
Phyllanthaceae			
Phyllanthus bernierianus *Müll.Arg.* var. glaber *Radcl.-Sm.*		M Z	
Proteaceae			
Protea enervis *Wild*		M Z	VU D2
Rubiaceae			
Empogona sp. nov. near E. congesta [1]		M Z	
Oldenlandia cana *Bremek.*		M Z	LC
Otiophora inyangana *N.E.Br.* subsp. parvifolia *(Verdc.) Puff*		M Z	
Otiophora lanceolata *Verdc.*	B	M Z	VU B1+B2
Rytigynia sp. D of FZ		Z	
Santalaceae			
Thesium bundiense *Hilliard*		Z	DD
Thesium chimanimaniense *Brenan*		M Z	LC
Thesium dolichomeres *Brenan*		M Z	LC
Thesium pygmeum *Hilliard*		M Z	LC
Scrophulariaceae			
Selago anatrichota *Hilliard*		M Z	LC
Thymelaeaceae			
Struthiola montana *B.Peterson*		M Z	DD
MONOCOTYLEDONS			
Asparagaceae			
Asparagus chimanimaniensis *Sebsebe*		M Z	LC
Eriospermum mackenii *Hook.f.* subsp. phippsii *(Wild) P.C.Perry*		M Z	
Sansevieria pedicellata *la Croix*		M	
Asphodelaceae			
Aloe ballii *Reynolds* var. ballii	A	Z	VU D2
Aloe ballii *Reynolds* var. makurupiniensis *A.Ellert*	A	M Z	VU D2
Aloe hazeliana *Reynolds* var. hazeliana [5]		M Z	LC
Aloe hazeliana *Reynolds* var. howmanii *(Reynolds) S.Carter* [5]		M Z	LC

Aloe munchii *Christian*		M Z	LC
Aloe plowesii *Reynolds*		M Z	VU D2
Aloe wildii *(Reynolds) Reynolds*		M Z	LC
Eriocaulaceae			
Mesanthemum africanum *Moldenke*	B	M Z	LC
Iridaceae			
Gladiolus juncifolius *Goldblatt*		Z	
Hesperantha ballii *Wild*		M Z	LC
Orchidaceae			
Angraecum chimanimaniense *G.Will.*		Z	
Disa chimanimaniensis *(H.P.Linder) H.P.Linder*		M Z	
Oligophyton drummondii *H.P.Linder & G.Will.*		Z	
Schizochilus calcaratus *P.J.Cribb & la Croix*		Z	
Poaceae			
Danthoniopsis chimanimaniensis *(J.B.Phipps) Clayton*	B	M Z	EN B1ab(iii)+2ab(iii)
Eragrostis desolata *Launert*		M Z	LC
Restionaceae			
Platycaulos quartziticola *(H.P.Linder) H.P.Linder & C.R.Hardy*		M Z	LC
Velloziaceae			
Xerophyta argentea *(Wild) L.B.Smith & Ayensu*		M Z	LC
Xyridaceae			
Xyris asterotricha *Lock*		M Z	VU D2
Xyris sp. nov. [1]		M	

[1] Still to be confirmed, but fairly certain to be different.

[2] Thought to be different from Namuli populations, but still to be confirmed. If found to be different the Chimanimani populations are not threatened and so become LC.

[3] Endemic, but only on schist (not quartzite).

[4] Lowland wetland endemic; not quartzite.

[5] From fieldwork it is not clear if these are taxonomically distinct.

A = only known from lower altitudes (<600 m); B = known from both low and higher altitudes.
Note: Source of threats for each species is given in Annex 2.

Figure 6.7. *Impatiens salpinx*, a quartzite endemic [BW].

Figure 6.8. *Morella chimanimaniana*, a schist endemic [BW].

Table 6.5. Number of endemic or near-endemic taxa in the Chimanimani area.

Category	no. taxa
Chimanimani montane endemic	70
Chimanimani montane near-endemic	20
Endemic to Umkondo sandstone areas around Chimanimani Mts	7
Chimanimani foothills endemic	8
Chimanimani foothills near-endemic	1
Manica Highlands endemic *	33
TOTAL	139

* = minimum number, probably more.

Endemism Levels

Although the high levels of plant endemism on the Chimanimani mountains have been known for many years, the first attempt to identify these appears to have been by Wild (1964) who listed 41 species considered endemic, some of which were first described in that paper. At the time there were thought to be 859 species above 4000 ft (1220 m) giving a level of endemism of 4.6%. Later studies, such as Mapaura & Timberlake (2002) in the Sabonet Red List (Golding 2002) followed by Mapaura (2002), gave a figure of 70 endemics (including Zimbabwe near-endemics if they were also found just over the border in the Mozambique part), with 56 of them said to be confined to quartzite grasslands. Using the most recent available figures for total species number (923 in Wursten *et al.*, in prep.) and the revised figure of strict Chimanimani endemics (78), gives us a level of endemism of 8.5%, higher than that of Mt Mulanje (at 5.4%; 71 endemics in a flora of 1319 species, Strugnell 2006, although some of these have since been found elsewhere). This compares to just 20 endemics in the broad Nyanga area further north (Clark *et al.* in press), 3 in the Vumba–Penhalonga–Stapleford area, and just 2 on Mt Gorongosa (V.R. Clarke, pers. comm., 2016). For south-central Africa the number of endemics confined to the Chimanimani mountains is very high indeed, making these mountains perhaps the highest-ranking 'hot spot' for endemics or range-restricted species, especially considering their limited extent of only 530 km^2 above 1000 m.

It is interesting to note that this exceptional high level of endemism is not seen in other groups of organisms. As noted in Section 4.5 above, there is one endemic amphibian, one endemic butterfly and possibly one endemic freshwater fish, but no endemic bird species. Only three of the birds recorded from the Chimanimani mountains are regarded as restricted-range, and only two are globally threatened species (Childes & Mundy 2001, Parker 2001).

Figure 6.9. *Polystachya valentina*, a Manica Highlands endemic [BW].

Figure 6.10. *Streptocarpus hirticapsa*, a Manica Highlands endemic [BW].

6.4 Assessment of Conservation Status

The conservation status of 82 of the species in our Chimanimani database was assessed at small workshops at Kew in 2015 and 2016 (see Annex 2); most of these assessments are provisional and still need to be reviewed. Of these, 66 relate to Chimanimani montane endemics or near-endemics.

As described earlier (Section 4.3), all herbarium specimens of the potentially "special" species held at Kew and in Harare (SRGH), along with collections from the 2014 trips (but not the 2016 trip), were databased using the BRAHMS programme (Filer 2016) and georeferenced. Localities were mostly taken from Google Earth and old maps; many of these localities are listed in Annex 3. Using Google Earth Pro the extent of the massif above 1000 m was estimated to be 528 km^2 of which 150 km^2 was identified from its rolling smooth texture as schist grassland and 112 km^2 as moderately densely wooded, leaving the extent of quartzite scrub and grassland and bare rock as 378 km^2. Using Kew's GeoCat tool (Bachman *et al.* 2011), distribution maps were made and the Extent of Occurrence (EOO) and Area of Occupancy (AOO) for each species calculated – the starting point for each assessment.

The following assumptions were made during the assessments:

- Following IUCN practice at the time, subspecies or varieties were not assessed unless data were available for all subspecific taxa for a full species-level assessment,
- AOO of widely-distributed quartzite endemics (grassland and scrub above 1000 m altitude) was a maximum of 266 km^2,
- AOO of schist grassland endemics was a maximum of 150 km^2,
- Montane protected areas in Zimbabwe and Mozambique were treated as separate locations; Forest Land in Zimbabwe was regarded as a separate location, as were commercial farmland, communal land and the TFCA buffer zone in Mozambique. Occurrences further afield (e.g. for Manica Highland endemics) were regarded as separate locations again,
- Species where habitat details or threats were unclear were regarded as Data Deficient,
- The major threat in recent years (i.e. within 3 generations of most assessed species in the mountains) has been the arrival of thousands of artisanal miners and associated traders. Prior to this there were no significant threats, i.e. populations were considered to have been stable.

As can be seen (Table 6.6, Annex 2), most of the 66 Chimanimani endemic/near-endemic taxa assessed (34 taxa, 52%) were considered to be Least Concern, primarily as they occur in protected areas on both sides of the border and their habitats are not particularly under threat from small-scale miners along the streams or from a possible increase in fire frequency. Of the 27 taxa (41%) considered to be under threat (CR, EN or VU), most were assessed as VU D2 owing to restricted distribution and a possible threat from increased fire frequency or human activity. Only five were considered Endangered – the grass *Danthoniopsis chimanimaniensis* owing to its streamside habitat, the herb *Raphionacme chimanimaniana* owing to its perceived rarity, the succulent *Euphorbia rugosiflora* owing to its very small population size and, at lower altitudes only, the climbing fig *Ficus muelleriana*. The Endangered herb *Rhynchosia chimanimaniensis* is a near-endemic and is threatened on nearby farmland.

In assessing the threat status of strictly montane species, for the great majority the main assumed threat was the loss of habitat owing to excavation of stream beds for gold or the clearance of caves for accommodation, or the increased frequency of wildfires (see columns on right side of Annex 2). All these factors are closely associated with the influx of small-scale miners and are described in more detail in Section 7. Habitat clearance is the main threat for species that also occur away from the main montane massif. We have assumed that although fire naturally occurs in grassland, scrub and woodland across the massif, its frequency has possibly increased over the last 20 years owing to the influx of artisanal miners and associated traders (see Section 7.2).

Table 6.6. Summary of conservation assessments of Chimanimani endemics and near-endemics.

IUCN Conservation category	**no. taxa**
CR	1 (B2)
EN	5 (B1+B2)
VU	21 (B1+B2 & D2)
NT	1
LC	34
DD	4
not assessed	33
TOTAL	99

If this assumed increase in fire frequency is found to be incorrect, or if the protected area management authorities can stop all mining activity and greatly reduce the number of people working or travelling through the mountains, then the threat level for many of the threatened taxa would drop significantly, in most cases from Vulnerable to Least Concern. However, if fire frequency does not decrease with reduced mining activity, or if similar destructive activities reoccur on the mountains, then the threat levels of many species would quickly rise to Vulnerable or even Endangered. It is important to note that the global populations of over 70 taxa are restricted to an area of less than 300 km^2.

Another uncertainty in the assessment process was with the smaller-leaved species of *Aloe*, the so-called ‘grass aloes’ such as *A. ballii*, *A. hazeliana* and *A. wildii* (see Reynolds 1966). We assumed that fire significantly affects their populations, hence increased fire frequency is a major threat, although they do tend to occur more frequently in fire-protected habitats such as on rocks. However, it is not clear if this is cause or effect, or to what extent they are destroyed by repeated fires, or what is the rapidity of recovery from rootstocks.

6.5 Ecology

The main ecological and vegetation findings are outlined here. Many of the original ideas on ecological determinants were described by Phipps & Goodier (1962) and we elaborate upon those where possible. A discussion on vegetation is given in Section 5 and threats to species are discussed later in Section 7.

Soils

As mentioned previously, nearly all the endemic taxa are confined to quartzite or quartzitic sandstone substrates, occurring on rocks and rock shelves, in crevices between large boulders, or on coarse sandy soils derived from sandstone. The sites where the greatest number are most likely to be found are among rocks or boulders, the so-called 'rock gardens', and on cliff ledges, often in what Phipps & Goodier (1962) called Ericaceous scrub. It is not clear whether it is the range of microhabitats available here (shade, protection from drying, freezing or from herbivores) that allows for this greater diversity, or whether protection from fire is a significant factor. In comparison, the extensive rolling grasslands – whether on red soils derived from schist or on poorly-drained coarse sandy or peaty soils derived from quartzite – are comparatively poorer in species. However, these are the main habitat for ground orchids and other large showy monocotyledons.

Wild (1964) not only pointed out the strong link between substrate and the presence of endemics, but also ascribed this to very low phosphorus levels in quartzite soils (less than 5 ppm compared to 500 ppm in schist soils, Phipps & Goodier 1962). There is also a difference between quartzite and schist substrates in the type of terrain and soils they weather to, as well as the actual mineral nutrient content.

Moisture

Climate is obviously a major factor determining both the distribution of vegetation types and plant species. The rocky slopes and boulder heaps must give much protection from extremes; temperatures in winter probably get below freezing at night. Although it can rain in almost any month, and low cloud and mists bring in moisture during the dry winter months, it is likely that many plants struggle for adequate moisture at times. In addition, coarse sandy and/or peaty soils can have very poor drainage, which inhibits root growth of a number of species. It may be this poor drainage and the resultant anaerobic soil conditions that precludes woody growth from all but well-drained sheltered positions.

The Zimbabwe side of the Chimanimani, across from the so-called ‘Second Ridge’ forming the ridge of main peaks, lies in a rain shadow as it is in the lee of the prevailing and moisture-bearing south-east airflows. But despite this, no significant difference in either vegetation or species composition has been noted.

Fire

From field observation, after substrate and climate the major ecological factor is probably fire. Herbivory may have been important until recently, but grazing levels are now very low as most large herbivores have been hunted out. This loss of grazers may now be allowing the build-up of greater fuel loads, making the open grasslands more readily combustible and with fiercer fires, although no clear evidence of this was seen. Certainly, the miombo and stunted open woodlands at slightly lower altitudes have a well-developed grass cover and regularly burn. What is not clear, and needs significant research, is how important fire has been in changing vegetation patterns up on the plateau.

Most of the Chimanimani endemics and species of particular conservation interest are found among quartzite or sandstone rocks and/or in the Ericaceous scrub habitat. Being quite flammable, such scrub is particularly susceptible to fire, but as it generally occurs among rocks it is harder for fire to spread across an area owing to the large gaps. In addition, smaller plants are protected deep in the cracks and can avoid some of its effects. Fire scars are commonly seen on woody plants in 'rock gardens', so protection, if it exists, is only relative and not absolute. And it is not uncommon to see evidence of a fire having run upslope through a bushy gully, presumably with a tail wind and exacerbated by its own heat. Fires can also spread rapidly and unimpeded across undulating grassland areas with adequate dry fuel loads, such as the schist grasslands.

It is not clear if fire is now actually more widespread and/or more frequent for any given area since the arrival of the gold-panners and associated traders some 12 years ago. There are so many more people moving through the area now than in the 1990s that this is definitely possible. Fire was certainly present before then and not uncommon, possibly related to itinerant hunters as well as those caused by lightening or similar natural events. With the exception of forest, all vegetation types and many of the species are adapted to fire, but more frequent or fiercer fires can change the boundaries and the balance.

It is still an open question as to whether the Ericaceous scrub habitat with its constituent endemics was more widespread in the past before fires possibly became more frequent. There appears to be little evidence for this either way, although it is quite possible that the extent of moist forest is now limited in part by fire. This can be seen in the 'hard' edges to many forest patches and the secondary nature of the forest fringe. Seedlings of forest species are nearly always found in shade inside the forest.

Again from field observation, it seems that many of the endemic species are adapted, perhaps even require, relatively open habitats; most are not found in shade. The large number growing in open habitats such as grassland and shrubland shows that these formations were extensive over recent evolutionary history and are not a recent phenomenon. Grassland and scrub must have been moderately widespread over a relatively long period in order for speciation to have occurred, suggesting that they have been an 'evolutionary factory' pre-dating the coming of modern humans. This inference differs from the suggestions in White (1978) for southern Africa, and Chapman & White (1970) specifically for Malawi, that most montane grassland has been derived from destruction of Afromontane forest by fire, much of it resulting from human activities. However, our suggestion is supported by and elaborated upon by Meadows & Linder (1993) in their assessment of forest and grassland dynamics since the Quaternary, based in part on palynological studies in the Nyanga area (Tomlinson 1973) in Zimbabwe, some 160 km to the north, and on the Nyika Plateau in northern Malawi (Meadows 1984).

Altitude

Although looked for, there appear to be hardly any species known only from altitudes above 1900 m, the most exposed and extreme environment on the mountains. *Streptocarpus montis-bingae* has only been recorded from sheltered crevices or caves above 2000 m, and the bulbous *Hesperanthera ballii* (Figure 6.10) only from above almost 1900 m. Slightly less extreme are *Crassula alticola*, *Protea caffra* subsp. *gazensis*, *Schistostephanum oxylobum* and *Helichrysum africanum* that are only recorded from above 1800 m up to 2300 m (only very occasionally below), while the low shrubby *Protea inermis* is known only from 1600–1900 m.

Figure 6.10. *Hesperanthera ballii*, quartzite endemic [BW].

Disturbance

It is also interesting to note the number of endemics that readily colonise or grow in disturbed habitats, such as *Mesanthemum africanum* along footpaths, *Thesium chimanimaniensis* in shallow pools left behind after mine workings, and *Crotalaria collina* on recent sandbanks after river disturbance. Although not endemic, *Plectranthus chimanimaniensis* (Figure 6.6) is very common, almost ubiquitous, at the bases of rocks, even where there has been marked disturbance.

Distribution

In conclusion, most of the endemics and 'Chimanimani specials' are quite widespread across the Chimanimani massif and can be found wherever there is suitable rocky or grassland habitat. Vegetation is better developed in more protected sites such as shaded and moist gullies (evergreen forest) and among rocks or on rocky slopes (Ericaceous scrub), while boggy conditions are found closer to drainage lines where there is a build-up of peat.

From our observations, no part of the mountain is more significant than any other as long as the necessary substrate is present. However, further to the south and southeast, the deep gorges seen were not visited – the vegetation here is obviously different. And below about 1000 m altitude the vegetation becomes increasingly dominated by various types of miombo woodland (*Brachystegia spiciformis* and/or *Uapaca kirkiana*, *Brachystegia tamarindoides* subsp. *microphylla*) with an associated decrease in the number of quartzite endemics, except in rocky exposed sites.

It is useful to note here that, despite the small-scale mining activity and wildfires, the ecological integrity of the Chimanimani Mountains appears to be good. There are threats, but the upland ecosystem at this stage seems to be able to repair itself, and no montane species are under long-term threat of extinction if these two threats can be removed or greatly reduced.

Quartzite crags, N Chimanimanis [BW].

7. THREATS AND CONSERVATION

One of the main objectives of the CEPF-funded study was to see if the endemic and other plant species of particular conservation interest were under threat from artisanal gold panning and mining activities across the Chimanimani massif. This section looks at the impacts of small-scale gold panning, the associated activities of the miners (called *gariemperos* in Mozambique), and describes other threats to biodiversity such as fire and alien invasive plants. Finally, issues such as climate change, currently-unprotected areas and conservation corridors are discussed.

7.1 Gold Panning

Although there has been a long (over 1000 years) history of gold mining across central Mozambique and parts of Zimbabwe, often linked to trade to the coast (Bannerman 2010, Dondeyne *et al.* 2009), there were no reports or evidence of gold mining or gold panning in the Chimanimani Mountains themselves until 12 years ago (Dondeyne *et al.* 2009). Recent gold panning in the higher Chimanimani area has been artisanal in nature, involving extraction of depositional (placer) gold from rivers and streams, although actual gold mines have existed for many years in areas further north near Vila Manica, Penhalonga and Mutare. It has been estimated that the output from artisanal gold-panning over the period 2007–2011 was in the range of 600–900 kg per year, with less than half of this being officially recorded. At an average price of USD 1000 per ounce ($ 35 per gram) this equalled USD 19–20 million per year (Dondeyne & Ndungaru 2014). As perhaps 60,000 people are involved in artisanal gold mining in Mozambique, this equates to an important income source. For example, it has been estimated that artisanal miners can earn USD 40–160 per month (Dondeyne *et al.* 2009), four times what a subsistence farmer in the region can earn. In recent years, this small-scale gold panning has started to impact upon the two conservation areas of Gorongosa National Park and the Chimanimani National Reserve in Mozambique, as well as on the Chimanimani National Park in Zimbabwe.

History of Gold Panning

In the Chimanimani Mountains the first reports of small-scale (and illegal, considering it is a protected area) Zimbabwean gold-panners in the Chimanimani National Reserve (the Core Zone of the TFCA) was in November 2004 (Ndunguru *et al.* 2006), followed by Mozambicans joining in November 2005. Soon after it was estimated that around 10,000 small-scale miners were working up in the mountains, with a daily production of 2–3 gm of gold per miner, equivalent to USD 32 million/year.

At that time, and even now, there were four main areas of activity (Figure 7.1) – on the upper reaches of the Rio Mufomodzi; below Mt Binga (Acampamento 1, Matimate – presumably named after a local miner); the (un-named) area and hills below Mawenje and peak BB71a (Acampamentos 2 to 4); the Ma-Esese (or Ma-SS) area around the extensive schist grasslands just east of The Saddle pass into Zimbabwe (Acampamento 5); and in the far south the Musange area (Acampamento 6). The extent of disturbance in these areas in 2006, estimated to cover an area of 39 km^2 (Dondeyne 2006b), is shown in Table 7.1 (Ndunguru *et al.* 2006).

A more recent study using Quickbird satellite imagery (Brooks & Couto 2009) showed that mining activity, although primarily along rivers, was changing. For example, 136 areas showed evidence of panning or mining activity in 2011 but not in 2005, while 113 areas were present on both dates. The number of sites showing activity (although it is not clear if this is current or historic) more than doubled over that period.

A major calamity befell many of the miners in a period of extremely bad weather in March 2006 during which at least 36 of them lost their lives (Ndunguru 2006). Talking to local sources in May 2016, the impression is given of more deaths, many of them Zimbabweans with no experience of mountain weather who died trying to cross flooded streams or from exposure to the cold and wet and from lack of food. A number are still buried there in caves.

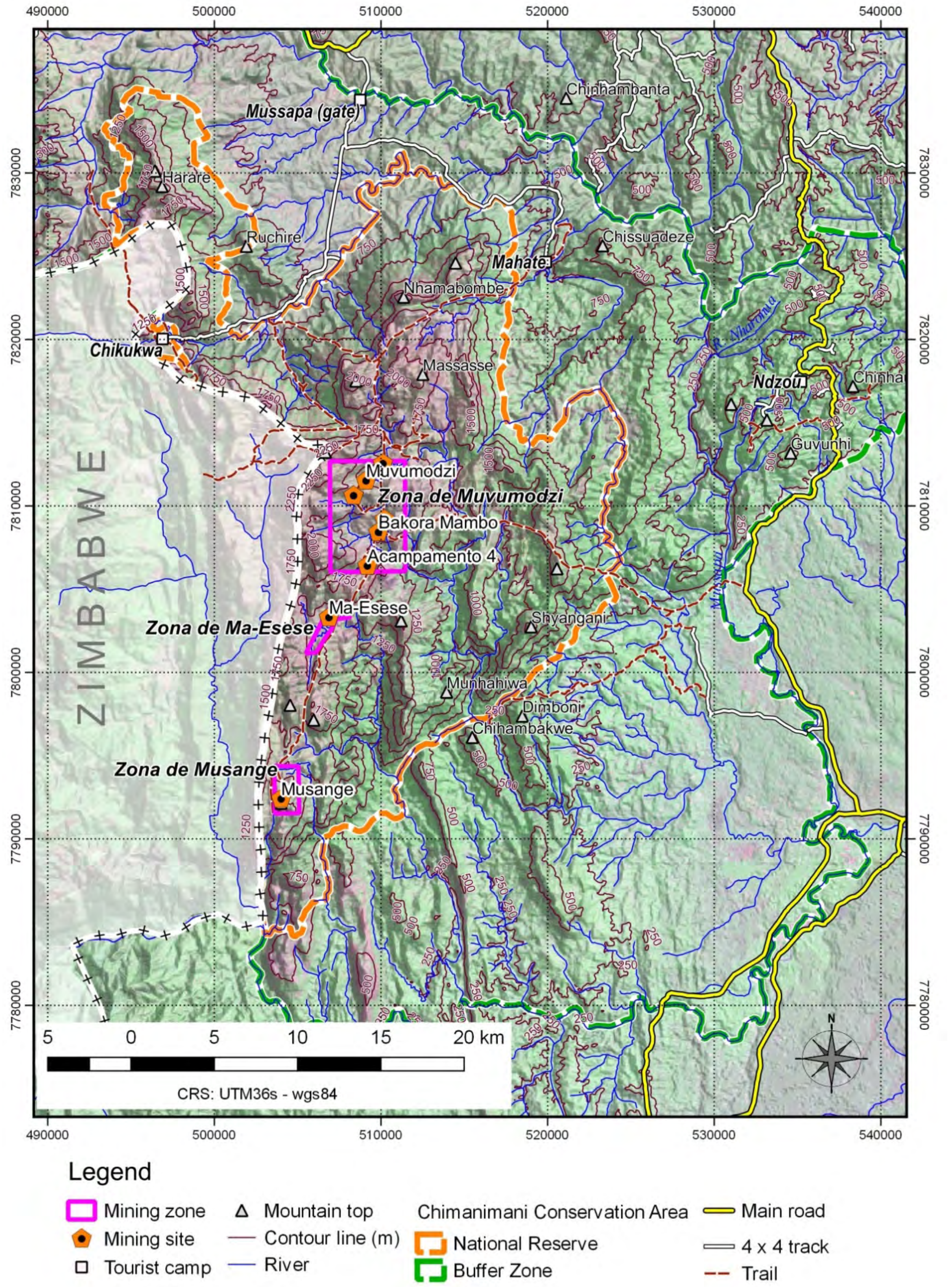


Figure 7.1. Principal mining zones in the Mozambique portion of Chimanimani mountains (S. Dondeyne, adapted from Ndunguru *et al.* 2006).

Table 7.1. Estimated density of gold-panners and impacts across Mozambique portion of the Chimanimani mountains, December 2006 (adapted from Ndunguru *et al.* 2006).

Zone	**Area (ha)**	**No. gold-panners**
Mufomodzi	3200	1500
Ma-Esese	250	100
Musange	450	400
TOTAL	3900	2000

Over the years the authorities have made numerous efforts to remove the artisanal gold-panners from the Chimanimani massif, but without success. There was a large raid on the Mozambique side in August 2006 which apparently reduced the number from an estimated 10,000 to around 2000 in December 2006 (Ndunguru *et al.* 2006). By March 2008 there were estimated to be 3000–5000 miners (Dondeyne 2008). Since 2006 efforts to reduce numbers on the Mozambique side appear to have been limited and relatively unsuccessful. The area is very large; there is plenty of advance warning of the arrival of large groups of scouts (fiscais) or other enforcement personnel coming up the mountain and there are many places to escape to, including over the border or into the forests below. Realistically it is not possible for the authorities to control such activity across the mountain unless many guards, perhaps 100, are stationed permanently up there (Dondeyne 2008b).

On the Zimbabwe side, which is much smaller (155 km^2 vs. perhaps 400 km^2 of montane area in Mozambique), control has been more rigorous, carried out through regular patrols of National Parks scouts. Apparently there are no small-scale gold-panners on the Zimbabwe side of the massif, although there are plenty at the base, e.g. on Charleswood farm. But evidence can be seen on Google Earth of past diggings in inaccessible areas close to the Mozambique border, for example near the summit of Mt Mawenje.

Initially, large acampamentos of miners, hence mining activity and environmental impacts, were confined to a few larger localities. One of the impacts arising from the clearances in 2006, when these concentrations of miners were broken up, was that mining activity was pushed into more numerous and less accessible areas. Hence the environmental damage footprint expanded. This is still apparent now.

No detailed estimates were made during the current project, but local guides suggest the number of miners is now (May 2016) around 1000. This is said to be due to the most readily accessible gold having been dug out rather than loss of interest or due to law-enforcement activities. Production levels are now way down on those reported in the early years. One local guide said that, in the best year, 1 kg of gold had been extracted every two weeks from the Mufomodzi area alone. But at present, production is said to be about 1 point (1/10th gram) per miner per day from many diggings (local questioning, Oct 2014).

7.2 Environmental Effects of Artisanal Mining

Gold extraction and processing is primarily carried out along rivers and small streams. Although there is destruction of riverine vegetation and increased sediment load leading to turbidity, as well as modification of depth and discharge of rivers up on the massif, the width of damage to vegetation is restricted by the size of the river bed and the length of working (Ndunguru *et al.* 2006). These diggings can be clearly seen on satellite imagery (Figures 7.2, 7.3). Because the soils are peaty with a medium to coarse-textured sandy subsoil, turbidity due to clay particles, so common at lowland sites, is minimal. The destruction of riverine vegetation, often involving stripping of grass clumps and turf from nearby areas to place in stream beds to divert water flow, has led to changed flow regimes and the formation of large sand banks downstream. It would seem that by far the largest environmental impact has been on aquatic life (vertebrates and especially invertebrates) rather than on plants.

There is no evidence or report of cyanide or mercury being used in the mountains, although mercury is used in artisanal mines elsewhere in Manica Province. In one area between Mufomodzi and Ma-Esese (around 19°48'55"S 33°05'14"E) the presence on a hillside of significant quantities of sharp, shattered rock showed that explosives had been used, although no evidence for this was seen elsewhere. It is clear that the main environmental damage from mining is confined to the stream excavations and changes in river hydrology.

Figures 7.2 & 7.3. Google Earth images (2011) of central plateau showing environmental damage from stream digging.

During fieldwork we specifically looked for any impacts of artisanal mining on the endemic plant species. Effects can be categorised as direct, owing to destruction or modification of habitat, or indirect resulting from changes in hydrology, drainage and microclimate, ancillary activities of the miners such as increased incidence of fire or firewood collection, or from the introduction of alien invasive species. These effects are discussed below.

Most of the Chimanimani endemics are associated with rocky quartzite outcrops and similar areas; very few are found either along streams or in wetter areas where the mining impact is most marked. Immediately alongside streams in some places, expanses (several square metres) of turf or grass clumps have been dug up to act as dam material to allow miners to access the underlying stream sediments. But none of the species of particular conservation interest are confined to this habitat.

Figure 7.4. Stream bed excavations by gold panners, north Chimanimani [JT].

Figure 7.5. Streambed destruction from gold diggings, central Chimanimani [JT].

Figure 7.6. Small-scale gold panning in stream, north Chimanimani [JT].

Figure 7.7. Gold panning in stream [JT].

One endemic, *Impatiens salpinx* (Figure 6.7), is commonly found in semi-shade along streambanks, but is also frequently found away from streams in similar damp sheltered sites (T. Shah, pers. comm.). Although its frequency and distribution may have been affected by mining activity over the last 12 years, it is not thought to be under significant threat (it was recently assessed as Vulnerable). As mining activity reduces owing to lower gold availability and stream banks become re-vegetated, it may well return to such sites.

Figure 7.8. The endemic *Mesanthemum africanum* [JT].

Another endemic, *Mesanthemum africanum* (Figure 7.8), appears to favour more open boggy habitats. It has also been found in the foothills along rivers in open habitats and on sandbanks, presumably arising from washed-down seeds. Surprisingly, it appears to have become locally more common in areas disturbed by mining activity, sometimes forming large flowering colonies in areas that were denuded just a few years ago, and is also commonly seen in wetter places along better-used footpaths.

Firewood

The upland area of the Chimanimanis, above the miombo woodland zone (upper limit generally 1000–1200 m), supports few trees apart from a few relatively small patches of Afromontane forest. Given the high number of small-scale miners present, the apparent lack of alternatives and the cold weather, it would be expected that most trees would have been cut as firewood. Surprisingly we did not find this to be the case, or at least there is little evidence for it except very locally. In one area (19°45'35"S 33°05'34"E, 1675 m) stumps of what appears to have been a small grove of stunted *Brachystegia spiciformis* were found, suggesting all had been cut down some years previously, but no other evidence of wholescale cutting was seen. Even around a complex of caves used for habitation at Matimate (the caves were said to have over 100 people living in them at one stage), a number of small trees are still found. This could be because many of the woody plants just do not make good firewood (e.g. *Schefflera goetzeniana*, often seen on small hillocks). Talking to miners and traders, it seems that firewood is sometimes brought in from woodland areas below, along with poles for construction of shelters.

One local source mentioned that *Xerophyta argentea* was a desired fuel source. Although small and fibrous rather than woody, it is relatively plentiful and the hard fibrous stem burns hot and slowly. However, no clear evidence was seen of its use. The species, another Chimanimani endemic, was recently assessed as Least Concern (T. Shah, pers. comm.) as it is locally abundant and does not appear to have been significantly affected by any harvesting.

Fire

Fire is undoubtedly a natural ecological factor across the mountains, but in the distant past natural fires (or even those caused by hunter-gatherers) were probably only occasional or infrequent at any particular site. The vegetation of the Chimanimani mountains is adapted to fire but we doubt if it has been totally shaped by it; its ecological effects are discussed in more detail in Section 6.5.

With the advent of artisanal mining over the last 12 years, it is probable that fire has become more frequent across much of the massif owing to the large number of people living there or travelling through. But what is not clear is how this assumed increase in fire frequency is impacting upon vegetation and on the species of particular interest. A few observations are given below.

During the drier months, it was possible to see a fire somewhere on the horizon almost every day, although most were limited in their extent (typically 0.5 to 2 ha). There are a number of small Afromontane forest patches scattered across the mountains, often on steep south- or west-facing slopes and adjacent to grassland areas. Fires sweeping through the grassland, with its significant fuel load and flammability during the dry season, come up against these forest patches with their scrubby and regenerating edges and kill or damage plants on the margin (Figure 7.9). Hence, over numerous years and after many fires, it is possible that forest margins may get 'hardened' or even pushed back, and regeneration or forest expansion becomes problematic. Damage to the scrubby margins, even if it does not consist of forest species, means more sunlight penetration and the undergrowth dries out more rapidly. This in turn inhibits growth and regeneration of shade-adapted forest species and the patch slowly gets smaller. This was noted as possibly having occurred in some areas, although it is not anywhere near as marked as the impacts of fire in parts of the Nyanga area in Eastern Zimbabwe.

At one locality close to the Rio Mufomodzi in central Chimanimani (19°48'21"S 33°08'43"E, 1260 m) a significant extent of what appear to be marginal Afromontane forest had been burnt through entirely and replaced by the invasive shrub *Vernonanthura phosphorica* (see below).

In the grassland areas, especially those on schist, it was often noted that small shrubs such as *Protea caffra* and *Morella chimanimaniana* have significant fire scars where above-ground shoots had been burnt back to the rootstock (T. Shah, pers. comm.). Although these species are fire-adapted and able to coppice readily, frequent fires (i.e. every year or two) are likely to weaken them. As regards the herbaceous flora, most growth takes place during the rainy season when the risk of fire is least. It is the species with above-ground perennial shoots that are likely to be affected most.

Figure 7.9. Wild fire on forest margin [JT].

Figure 7.10. Cave used by miners for shelter [JT].

Field observation suggests that the present patches of Ericaceous scrub and 'rock garden' vegetation are found primarily in more fire-protected situations such as rocky areas and boulder slopes. But it is not clear if this is an effect of fire or due to better drainage and more suitable microhabitats for regeneration, or other similar factor. Many *Aloe* species, common constituents of rock gardens, are, for example, quite sensitive to fire, as are other succulents. Only local evidence was seen, however, of charred stems on woody plants in these areas.

Caves & Settlements
There are many caves throughout the quartzite areas of the Chimanimani mountains, mostly shallow rock shelters and overhangs. Historically these have been used as shelter for visitors and those travelling through, and up on the plateau there appears to be no evidence they were used for more permanent habitation in the past.

Over the last 12 years with the influx of both miners and traders, these caves have become heavily used, sometimes for some years. Fires inside have blackened many walls and roofs, small stone walls have been built and floor areas flattened for sleeping (Figure 7.10). Populations of moisture- and shade-loving plants such as *Streptocarpus* species in the back of caves have been lost, but we noted that in some cases species such as *S. hirticapsa* have re-established themselves quite rapidly within a year or two of the cave being abandoned.

Another concern with the widespread use of caves for longer-term habitation is the introduction of exotic and domestic species. Many caves had ruderals growing in or near the entrance, species such as tomato (*Solanum lycopersicum*), Cape Gooseberry (*Physalis peruviana*), *Cannabis sativa*, *Amaranthus* sp., *Phytolacca* sp., *Galinsoga* sp., *Sonchus* sp. and *Bidens pilosa*. But it is probable that these exotics will die out over the years and will not establish viable populations.

Other Threats
As well as the miners living in the mountains there are many hundreds of traders and suppliers travelling through the area (Figure 7.11), both from local communities in the foothills such as Maronga and Zomba or from further afield such as Chikukwa on the border, Chimanimani town, or even other parts of Zimbabwe and Mozambique. The promise of ready money has attracted small traders from across a large area. The influx of people and goods has

also brought in a fair amount of rubbish, some biodegradable but a lot of it (plastic wrappings, drink containers) not. Although probably having little direct biological impact, the mountains become less attractive for tourists, most of who come for a wilderness experience.

Figure 7.11. Small store servicing miners, central Chimanimani [JT].

7.3 Alien Invasive Plants

Compared to some montane areas such as Nyanga National Park in Zimbabwe, the upland Chimanimani area is remarkably free of alien invasive species, especially considering the disturbance in recent years and numbers of people passing through. This is probably due to the very nutrient-deficient environment which precludes most species getting established. However, there are some records of alien species, particularly in more nutrient-enriched sites.

The invasive species of greatest concern is the large Compositae shrub, *Vernonanthura phosphorica* (Timberlake *et al.* 2016). This highly invasive species is mostly found below 1000 m altitude in disturbed forest or cleared forest areas in the foothills. However, a large stand of over 20 ha was seen in a patch of destroyed forest along the middle reaches of the Rio Mufomodzi (19°48'29"S 33°08'42"E, 1230 m). Occasional plants have also been seen around caves used for habitation (19°47'10"S 33°05'21"E, 1660 m and 19°50'22"S 33°05'11", 1420 m) at significantly higher altitudes. Although it is primarily a species that comes in on humus-rich soils after forest destruction, it should be looked out for and control measures taken when appropriate. Once established it tends to crowd or shade out most other species.

The spread of *Pinus patula* is a major problem in Nyanga National Park and pines, *P. patula*, *P. taeda* and *P. elliottii*, are also extensively planted commercially around Chimanimani (e.g. in Martin, Tarka, Chisengu Forest Land) in Zimbabwe. There are no commercial plantations near to the Chimanimani massif in Mozambique, the nearest being Ifloma at Rotanda. Some occasional trees of *Pinus patula* were seen in the Mozambique portion of the mountains (e.g. at 19°45'33"S 33°05'17"E, 1750 m and 19°45'44"S 33°04'32", 1575 m), including a mature tree with cones, but these are isolated individuals. A careful look should be kept out for potentially invasive pines, especially on rocky slopes, but it does appear to be a low risk.

At one site (19°52'07"S 33°03'27"E) a lone *Eucalyptus* tree 4 m high was seen at what was an old market place where gold had been traded. It was probably established (planted?) at least 6 years ago and can survive harsh winters. Wattle (*Acacia mearnsii*) was not seen at all.

So far the very invasive *Rubus ellipticus* (Himalayan Raspberry), such a problem on Mt Mulanje and the Zomba plateau in southern Malawi and on the Nyika plateau in northern Malawi, has not been noted. If it is, immediate steps should be taken to eradicate it. Other native *Rubus* species seen on the plateau are not considered to be invasive.

Species that have established in cave entrances and along footpaths, including common weeds such as *Bidens pilosa*, do not appear to be spreading. They are unlikely to become invasive or a significant presence other than in locally-enriched, disturbed sites.

7.4 Climate Change

For nearly all the endemics, it is unlikely they could establish themselves on non-quartzite substrates for more than a generation, hence there is little possibility of range expansion or successful introduction to other mountains. The Chimanimani mountains are their only possible habitat. Climate change, specifically increasing mean temperatures and decreasing rainfall, may well become an issue for conservation of the endemics in the future, but there is no evidence that this is an acute situation at present. The quartzite substrate covers a wide altitudinal range – from under 300 m to 2400 m – so species and vegetation types can move their altitudinal ranges; indeed, a few quartzite endemics have been found at much lower altitudes on small quartzite outcrops or along rivers in more open habitats (Timberlake *et al.* 2016). There is possibly only one species (*Streptocarpus montis-bingae*) that is found only at high altitudes (above 2000 m), such that a warmer climate may push it out of its climatic envelope (see Section 6.5). If the climate becomes drier and hotter it is possible that the main plateau (1000–1800 m), and of course areas lower down, may become too dry for many of the endemics, except perhaps in isolated favourable sites. Populations may then decline markedly, although total extinction is unlikely over the next 100 years.

7.5 Unprotected Habitat and Corridors

Surprisingly little habitat suitable for the Chimanimani endemics is not already protected in one way or another. In Zimbabwe all quartzite and schist habitat suitable for the endemic species falls within the Chimanimani National Park, but in Mozambique there is a small exclusion from the TFCA Core Zone of around 330 ha in the Mussapa Gap area (1100–1250 m altitude), presumably to allow for existing fields and settlement along this important trade route. In addition, in the south and at a much lower altitude (350–500 m) in the Maronga area, two long quartzite ridges totalling around 3200 ha – mostly covered in woodland, but which are known to support a few of the endemic species (Timberlake *et al.* 2016) – fall outside the TFCA Core Zone but within the Buffer Zone. With a combined total of around 35 km^2, this represents less than 7% of the total quartzite habitat, although the largest part of this, being primarily woodland with moist forest patches, is not suitable for most endemics.

Corridors are often an issue in conservation, but in this case not only is nearly all the potential suitable habitat for both the montane flora and the endemics already protected, and not under any imminent threat, but it also forms a contiguous block. There might be an issue with continuity of montane habitat for some near-endemics and Manica Highland endemics between the Chimanimani Mountains, Chirinda Forest, Mt Gorongosa, Tsetserra, Vumba and Nyanga, but there is no evidence that this is a particular problem as regards plants. However, it is likely to be so for smaller less-mobile animals such as reptiles and amphibians. This discontinuity has been present on the Zimbabwe side for over 100 years since wide-scale clearance for settler farms, a situation that is unlikely to change. In addition, the land and soils in such areas may now not be viable or particularly suited to biodiversity conservation.

7.6 Wildlife and Wildlife Habitats

This topic was not specifically looked at during our study. However, a few general comments can be made.

As the habitats required by wildlife species are nearly all still present and in good condition, given protection most mammal populations could probably return rapidly. But this assumes there are still sufficient numbers still around to form a viable breeding population.

Of greater concern are the fish species, which will have been much more badly affected by disruption of stream flows from small-scale mining activity, increased turbidity of water, perhaps an increase in water nutrient content, and a probable loss or diminution of aquatic invertebrate food resources.

View over northern Chimanimani [JO].

8. MAIN FINDINGS

1. Using older checklists from Zimbabwe, along with collections made under this project, we estimate there are over 920 plant species and subspecies found in the mountains above 1200 m altitude. As a result of the recent survey nine new species may have been discovered (subject to confirmation). These need to be studied further and written up to become scientifically validated.

2. There are now known to be at least 78 species or subspecies endemic to the Chimanimani Mountains, an endemism level of 8.5%. Most are found across the mountain and on both sides of the international border, but nearly all of them are restricted to soils derived from the typical white quartzite sandstone rock. A very few are known only from lower altitudes on the mountains.

3. The main habitat for the endemics and other species of conservation interest are small hills, rocky outcrops and cliffs, and 'rock gardens' composed of white quartzite rock, which are found across the mountain range. The extensive grasslands on soils derived from schist rocks support many fewer species of interest, although they are richer in ground orchids.

4. The Core Zone of the Chimanimani National Reserve in Mozambique is ecologically intact and adequate for conservation of the unique flora of the Chimanimani Mountains, as long as all illegal activities can be controlled.

5. Very few wild animals were seen, especially considering the large herds reported in the 1960s. This is presumably due to increased human activity across the mountains, although no evidence of snaring was seen. The wildlife habitats are considered still sufficiently intact for vertebrate populations to recover, if there are adequate numbers remaining.

6. Conservation assessments using IUCN Red List criteria were carried out on 66 endemic or near-endemic species from the Chimanimani area. Of these 34 were considered to be of Least Concern (i.e. not under threat), while 27 were considered threatened (21 Vulnerable, 5 Endangered, 1 Critically Endangered) and 4 were considered Data Deficient owing to inadequate information. In general, plant species on the Chimanimani Mountains are not under particular threat, except for those with specific habitat requirements that are being affected by the recent increases in mining and human activity.

7. Gold-panning activity is concentrated in four main areas – the upper Rio Mufomodzi, below Mawenje peak, Ma-Esese and Musange. In addition to the significant number of gariemperos (illegal gold-panners) working there, many itinerant traders from both Zimbabwe and Mozambique service them. However, the number of people present is believed to be much reduced from that in 2008–2009, with possibly only around 1000 miners now. No evidence of the use of mercury or cyanide was seen, although in one area explosives had been used.

8. The impacts of illegal gold panning over the last 12 years appear to be having a very large and deleterious effect on upland hydrology and on aquatic organisms and ecology, also reducing the value of the area as a water catchment. However, as this project was looking primarily at impacts on plants, no confirmatory data were collected on impacts on aquatic vertebrates and invertebrates.

9. Surprisingly, there appears to have been little obvious impact of mining activity on the native vegetation and endemic plants, despite the clear visual impact on the landscape. Impacts are primarily confined to a few metres each side of the watercourse. One endemic herb, *Mesanthemum africanum* (Eriocaulaceae), has greatly expanded its population size as it readily colonises the bare areas caused by digging on stream banks and along footpaths.

10. Although not confirmed, there is a possible indirect impact from the assumed increase in wildfire frequency on the patches of shrubby vegetation on rocky slopes (Ericaceous scrub), and perhaps also on some of the woody grassland species found in extensive grassland areas. It is this shrubby vegetation which contains many of the endemic species, although they are partly protected from fire owing to the many crevices and gaps in the rocks which inhibit its rapid spread. There is also evidence of fire eating into or 'hardening' the margins of the small moist forest patches across the mountain, slowly making them smaller.

11. Little evidence was seen of recent tree cutting or cutting of other plants for fuelwood. Considering the numbers of people living up in the mountains from 2006 to 2016, the damage does not appear great. Some reports suggest that the tufted endemic herb *Xerophyta argentea* growing on rocks has been used as a fuel, but no evidence of its widespread use was seen. It seems that at least some construction wood for shelters and firewood is brought up from the woodlands below.

12. The invasive shrub *Vernonanthura phosphorica* (Asteraceae) is spreading widely into areas on the lower Chimanimani footslopes where forests have been destroyed or damaged for agriculture. A few individuals of this species are also found at higher altitudes (1200–1400 m) in disturbed areas and in patches of fire-damaged forest. This is considered to be a potentially serious problem, at least at lower altitudes in both the core and buffer zones. Another potentially invasive species, *Pinus patula*, was seen, but does not appear to be spreading or a problem at this time. Frequent fires and disturbance may well assist its spread. Some weeds and domesticated plant species were noted in caves that had been inhabited, and along larger footpaths.

13. The wilderness experience for tourists has been damaged. Not only are there many people moving across the mountain, even at night, but there can be a sense of mild fear and distrust between the small-scale miners and tourists which can lead to misunderstandings and problems. In addition, there are now significant levels of litter scattered by footpaths across the mountains and many of the caves used as overnight accommodation have become rather messy and unattractive to visitors.

9. RECOMMENDATIONS

Research

1. Although most management and plant conservation activities in the montane areas can now proceed without any additional research, it would be useful to investigate whether there has been any population decline in any of the important plant species, or if there is any developing threat resulting from human activities. Of particular concern is the long-term impact of any increase in fire frequency.

2. There is a need for a biological monitoring programme to be set up that would look at any species that might be under threat from human activity or environmental change. In upland areas such a programme should focus in particular on (a) the extent and condition of Ericoid scrub, (b) the extent of the scattered moist forest patches, and (c) the frequency of wildfires and which areas are being burnt.

3. Research is required into the distribution and spread of alien invasive species, especially *Vernonanthura*, as well as a monitoring programme.

4. Of major importance is to determine the effects of the gold-panning activities on the hydrology of the nutrient-poor upland streams and rivers and on the invertebrates and vertebrates living there, along with any possible amelioration measures that can be taken. This is now possibly the biggest conservation concern in the upland area.

Management

5. The destructive effects of small-scale mining need to be regulated, but it is recognised that this is difficult. Control of the digging out of stream beds is of particular concern for the conservation of aquatic organisms, aquatic ecology and hydrological processes.

6. Although this is mostly outside of the montane study area, there is an urgent need to control the expansion of forest clearance for subsistence agriculture on the lower eastern slopes of the lower Core Zone of the TFCA and in the Buffer Zone, especially as this is usually accompanied by extensive wildfires and accelerated soil erosion. Existing agricultural practices in the Buffer Zone (Zona Tampão) need to be improved as a matter of urgency.

7. There needs to be some control on the extent and frequency of wildfires, especially around forest and shrubby patches up on the Chimanimani massif. It is not recommended that fire-breaks are constructed, but perhaps control could be partly achieved through awareness-raising and education of the communities living along the footslopes, and of the miners themselves.

8. At medium altitudes (800–1200 m), a programme for the control of invasive alien species will be required, particularly for *Vernonanthura* which is expanding rapidly and invading damaged moist forest patches.

9. The routes of tourist trails should be determined mostly by logistics and accessibility, scenery, water supply and suitable camps or caves to stay in. For plants, the attractive 'rock gardens' are widespread across the montane area on both sides of the international border and are not confined to particular areas.

10. Many caves suitable for staying in overnight are found, but most appear to have been heavily used by miners and associated traders in recent years. There are blackened roofs, scattered rubbish and weeds at the entrance. If tourists and visitors are to use them, the caves will need to be cleaned out.


Stream after being dug out by gold-panners, central Chimanimani [JT].


Expedition campsite at foot of Mt Binga [JT].

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View over eastern Chimanimanis [BW].

11. REFERENCES AND BIBLIOGRAPHY

Agritex/FAO (1989). Agro-climatological summaries and analysis (rainfall and potential evapotranspiration), Vols. I & II. Agritex/FAO, Early Warning/Food Security Unit, Harare, Zimbabwe.

Anderson, N. (1965). Chironi Expedition (Chimanimani area). Prince Edward School expedition. Rhodesian Schools Exploration Society report, pp. 21–24. Harare [Salisbury], Zimbabwe.

Anon. (n.d.). Chimanimani Transfrontier Conservation Area. SADC/ German Cooperation/ giz. 2 pp brochure. https://www.giz.de/en/downloads/giz2015-en-tfca-chimanimani.pdf, accessed March 2016.

Bachman S., Moat J., Hill A.W., de la Torre J. & Scott B. (2011). Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. *ZooKeys* **150**: 117–126. doi: 10.3897/zookeys.150.210

Ball, J.S. (1978). *Southern African Epiphytic Orchids*. Conservation Press, Johannesburg, South Africa.

Bannerman, J.H. (2010). Appendix 1. The human population: history, culture, land use and traditional structures. In: *Chimanimani National Reserve. Management Plan* (A. Ghiurghi, S. Dondeyne & J.H. Bannerman), volume 3. Report prepared by AgriConsulting for Ministry of Tourism, Maputo, Mozambique.

Barbosa, L.A.G. (1952). Esboço da Vegetação da Zambézia. Separate from Documentário Moçambique No. 69. Centro de Investigação Científica Algodoeira, Lourenço Marques.

Barbosa, L.A.G. (1968). Moçambique. In: I. Hedberg & O. Hedberg (eds.) Conservation of Vegetation in Africa South of the Sahara. *Acta Phytogeographica Suecia* **54**: 224–232.

Beard, J.S. (1992). *The Proteas of Tropical Africa*. Kangaroo Press, New South Wales, Australia.

Bell, R.H.V. (1999). Management Plan. Volume 1, Recommendations for the Future. Report prepared for Transfrontier Conservation Area Project by the National Directorate of Forests and Wildlife with support from the GEF, Maputo, Mozambique.

Bond, G. (1952). Structure and metamorphism in the Chimanimani Mountains. *Transactions & Proceedings Geological Society of South Africa* **54**: 69–83.

Broadley, D.G. & Blake, D. (1973). Checklist of the reptiles and amphibians of the Chimanimani mountains. Unpublished report. National Museums of Rhodesia.

Broadley, D.G. (1974). The Lusitu Forest – a new protected area. *Wild Rhodesia* **3**: 17.

Brooks, K. & Couto, M. (2009). Mission with Chimanimani National Reserve: Conducting change detection in Chimanimani National Preserve, Mozambique. GISCorps. http://www.giscorps.org/index.php?option=com_content&task=view&id=118&Itemid=63 (accessed 15 Dec 2014).

Burrows, J. & Burrows, S. (2003). *Figs of Southern and South-Central Africa*. Umdaus Press, Hatfield, South Africa.

Capela, P. (2006). *Speculations on the* Encephalartos *Species of Mozambique*. Privately published, Chimoio, Mozambique.

CEPF (2012). Ecosystem Profile: Eastern Afromontane Biodiveristy Hotspot. Critical Ecosystem Partnership Fund/BirdLife International, Nairobi.

Chapano, C.& Mamuto, M. (2003). Plants of Chimanimani District. 97 pp. National Herbarium & Botanic Garden, Harare, Zimbabwe.

Chapman, J.D. & White, F. (1970). *The Evergreen Forests of Malawi*. Commonealth Forestry Institute, Oxford.

Childes, S.L. & Mundy, P.J. (2001). Zimbabwe. In: *Important Bird Areas in Africa and Associated Islands: Priority Sites for Conservation* (eds. L.D.C. Fishpool & M.I. Evans), pp. 1025–1042. Pisces Publications & BirdLife International, Newbury & Cambridge, UK.

Clark, V.R., Timberlake, J.R., Hyde, M.A., Mapaura, A., Coates Palgrave, M., Wursten, B.T., Ballings, P., Burrows, J.E., Linder, H.P., McGregor, G.K., Chapano, C., Plowes, D.C.H., Childes, S.L., Dondeyne, S., Barker, N.P. & Müller, T. (in press). A first comprehensive account of floristic diversity and endemism on the Nyanga massif, Manica Highlands (Zimbabwe–Mozambique). *Kirkia* **19** (accepted for publication).

Crook, A.O. (1956). A preliminary vegetation map of the Melsetter Intensive Conservation Area, Southern Rhodesia. *Rhodesia Agriculture Journal* **53**: 3–25.

Darbyshire, I. & Massingue, A.O. (2014). Two new species of *Streptocarpus* (Gesneriaceae) from tropical Africa. *Edinburgh Journal of Botany* **71**: 3–13.

Davis, S.D., Heywood, V.H. & Hamilton, A.C. (1994). Chimanimani Mountains. In: *Centres of Plant Diversity: A Guide and Strategy for Their Conservation*. Volume 1: Europe, Africa, South West Asia and the Middle East, p. 139. WWF & IUCN, IUCN Publications Unit, Cambridge, UK.

Dondeyne, S. & Ndunguru, E. (2014). Artisanal gold mining and rural development policies in Mozambique: Perspectives for the future. *Futures* **62**: 120–127.

Dondeyne, S. (2008a). Report on visit to illegal gold mining site ‘Acampamento No.1’ along the Muvumodzi, Chimanimani National Reserve. Unpublished draft report, March 2008.

Dondeyne, S. (2008b). Report on 2nd visit to illegal gold mining site ‘Acampamento No.1’ along the Muvumodzi, Chimanimani National Reserve. Unpublished draft report, 14 April 2008.

Dondeyne, S., Ndunguru, E., Rafael, P. & Bannerman, J. (2009). Artisanal mining in central Mozambique: Policy and environmental issues of concern. *Resources Policy* **34**: 45–50.

Dondeyne, S., Vancampenhout, K., Nhantumbo, N. & Deckers, S. (2011). Forests of the Chimanimani Transfrontier Conservation Area: Their value for conservation and potential for climate change mitigation. Poster presented at Conservation and Management of Forests for Sustainable Development, Leuven, Belgium, 23–24 November 2011.

Dondeyne, S., Wursten, B. & Bannerman, J. (2009). Photographic checklist of the vascular plants of the Chimanimani Conservation Area. Provisional version – Annex to the Management Plan. 140 pp.

Dutton, T.P. & Dutton, E.A.R. (1975). Reconhecimento preliminar das montanhas de Chimanimani e zonas adjacentes com vista à criação duma área de conservação. *Anais do Serviços do Veterinária de Moçambique* **20/21**: 123–203.

Ellert, A. (2008). *Aloe perdita*, a long-lost species from the Chimanimani Mountains on the Zimbabwe/Moçambique border. *Aloe* **45**: 76–77.

Farjon, A. (2010). *A Handbook of the World's Conifers*, Vol. 2. Brill, Leiden, Netherlands.

Farjon, A. & Filer, D. (2013). *An Atlas of the World's Conifers: An Analysis of their Distribution, Biogeography, Diversity and Conservation Status*. Brill, Leiden, Netherlands.

Filer, D. (2016). BRAHMS, Botanical Research and Herbarium Management System, ver. 7. Department of Plant Sciences, University of Oxford, UK. Available at http://herbaria.plants.ox.ac.uk/bol/

Garlake, P. (1995). *The Hunter's Vision: The prehistoric art of Zimbabwe*. Zimbabwe Publishing House, Harare/British Museum Press, London.

GeoterraImage (Pty) Ltd. (2008). Land-Cover Classification for Peace Parks Foundation: Chimanimani dataset. Final Data Report and Meta Data (vs. 1). Report for Peace Parks Foundation, Stellenbosch, South Africa.

Ghiurghi, A., Dondeyne, S. & Bannerman, J.H. (2010a). *Chimanimani National Reserve. Management Plan*, volume 1. Report prepared by AgriConsulting for Ministry of Tourism, Maputo, Mozambique.

Ghiurghi, A., Dondeyne, S. & Bannerman, J.H. (2010b). Appendix 6, List of rare and endangered plants of Chimanimani Conservation Area. In: *Chimanimani National Reserve. Management Plan*, volume 3. Report prepared by AgriConsulting for Ministry of Tourism, Maputo, Mozambique.

Gilliland, H.B. (1938). The vegetation of Rhodesian Manicaland. *Journal of South African Botany* **4**: 73–100.

Gomes e Sousa, A. (1968). Reservas florestais de Moçambique. Comunicações 10. Instituto de Investigação Agronómica de Moçambique, Maputo.

Goodier, R. & Phipps, J.B. (1958). A first check-list of the vascular plants of the Chimanimani Mountains. *Proceedings & Transactions Rhodesian Scientific Association* **46**: 147–163.

Goodier, R. & Phipps, J.B. (1961). A revised check-list of the vascular plants of the Chimanimani mountains. *Kirkia* **1**: 44–66.

Goodier, R. & Phipps, J.B. (1962). A vegetation map of the Chimanimani National Park. *Kirkia* **3**: 2–7.

Goodier, R. (2007). A revised list of the endemic plant taxa of the Chimanimani mountains. Revised by J. Timberlake, November 2014. Unpublished report.

Goodier, R. (2009). The danger of noticing the flowers (or how I nearly gave up climbing and became a botanist – an African interlude). *Climbers' Club Journal* **27**(122): 24–28. Available at http://www.climbers-club.co.uk/journal/original/2006-07-Journal-p24-28.pdf

Hadj-Hammou, J. (2014). Field guide to the endemic plants of the Chimanimani area. Unpublished manuscript. RBG Kew, London.

Hatton, J. & Munguambe, E. (1997). First National Report on the Conservation of Biological Diversity in Mozambique. MICOA, Maputo, Mozambique.

Hedberg, O. (1951). Vegetation belts of the East-African mountains. *Svensk Botanisk Tidskrift* **45**: 140–202.

Hilliard, O.M. & Burtt, B.L. (1990). Studies in the Gesneriaceae of the Old World. LI, A new *Streptocarpus* from Mozambique. *Notes Royal Botanic Gardens Edinburgh* **46**: 321–322.

Hodgson, C.J. (1971). The birds of the Chimanimani Mountains, Rhodesia. South African Avifauna series No. 77: 1–31.

Howes. R.G. (1990). Stop Press – caves in Zimbabwe. *South African Speleological Association Bulletin* **30**: 88.

Hughes, D.M. (2001). Rezoned for business: How eco-tourism unlocked Black farmland in Eastern Zimbabwe. *Journal of Agrarian Change* **1**: 575–599.

Hughes, D.M. (2007). *From Enslavement to Environmentalism: Politics on a Southern African Frontier*. University of Washington Press, Seattle, USA / Weaver Press, Harare, Zimbabwe.

Hughes, J. & Gunns, D. (1973). Archaeology. In: December, 1972–August, 1973 Expedition. "The Corner" – Chimanimani Mountains. Rhodesian Schools Exploration Society (Mashonaland), Harare [Salisbury], Zimbabwe.

Huntley, B. (1978). Ecosystem conservation in southern Africa. In: *Biogeography and Ecology of Southern Africa* (edited by M.J.A. Werger). W. Junk, The Hague, Netherlands. pp. 1333–1384.

Hyde, M.A., Wursten, B.T., Ballings, P. & Coates Palgrave, M. (2015). Flora of Zimbabwe website. http://www.zimbabweflora.co.zw/

Hyde, M.A., Wursten, B.T., Ballings, P., Dondeyne, S. & Coates Palgrave, M. (2015). Flora of Mozambique website. http://www.mozambiqueflora.com/

I.N.G. (1987). Carta Geologica, scale 1:1 million. Instituto Nacional de Geologia, Maputo.

IUCN (2001). IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.

Izidine, S. & Bandiera, S. (2002). Mozambique. In: *Southern African Plant Red Data Lists* (edited by J.S. Golding), pp. 43–60. Report no. 14. SABONET, Pretoria, South Africa.

Jackson, H.D. (1973). Records of some birds and mammals in the central Chimanimani mountains of Moçambique and Rhodesia. *Novitates (Durban Museum)* **9**(20): 291–305.

Key, R.M., Cotterill, F.P.D. & Moore, A.E. (2015). The Zambezi River: An archive of tectonic events linked to the amalgamation and disruption of Gondwana and subsequent evolution of the African plate. *South African Journal of Geology* **118**: 425–438.

Killick, D.J.B. (1978). The Afro-alpine region. In: *Biogeography and Ecology of Southern Africa* (edited by M.J.A. Werger), pp. 515–560. W. Junk, The Hague, Netherlands.

King, L.C. (1962). *Morphology of the Earth: A Study and Synthesis of World Scenery*. Oliver & Boyd, Edinburgh.

Koliasnikoff, A. (1994). The Frontier Shafts area: New surface reconnaissance. *Bulletin of the South African Speleological Association* **35**: 8–13.

Le Roux, J.P. *et al.* (1993). The 1992 Chimanimani Caving Expedition. Expedition Report, South African Speleological Association, Cape Town, South Africa.

Linder, H.P. (2014). The evolution of African plant diversity. *Frontiers in Ecology & Evolution* **2**(38): 1–14.

Lister, L.A. (1987). *The Erosion Surfaces of Zimbabwes*. Zimbabwe Geological Survey Bulletin No. 90. Geological Survey, Harare.

Little, I.T. (2013). Mozambique and Malawi Blue Swallow survey report, 10–31 November 2013. Endangered Wildlife Trust, Johannesburg.

Magness, T.A. [editor] (1973). Vakwashi (the hunters of knowledge): Expedition to the Hode People. Report from the Vakwashi Branch, Rhodesian Schools Exploration Society. Harare [Salisbury], Zimbabwe.

Mapaura, A. & Timberlake, J.R. (2002). Zimbabwe. In: *Southern African Plant Red Data Lists* (edited by J.S. Golding), pp. 157–182. Report no. 14. SABONET, Pretoria, South Africa.

Mapaura, A. (2002). Endemic plant species of Zimbabwe. *Kirkia* **18**: 117–148.

McCracken, J. (2006). Imagining the Nyika Plateau: Laurens van der Post, the Phoka and the making of a National Park. *Journal of South African Studies* **32**: 807–821.

Meadows, M.E. (1984). Late Quaternary vegetation history of the Nyika Plateau, Malawi. *Journal of Biogeography* **11**: 209–222.

Meadows, M.E. & Linder, H.P. (1993). A paleoecological perspective on the origin of Afromontane grasslands. *Journal of Biogeography* **20**: 345–355.

Mitchell, D.S., Hall, A.V., *et al.* (1958). The 1958 Science Society Expedition to the Chimanimani Mountains. *Journal of Science Society, University of Cape Town* **1**: 25–37.

Monteiro, J., Dondeyne, S., Wursten, B., Bannerman, J., Melby, H. & Sitoe, A. (2011). Vegetation composition of natural gaps in Moribane forest (Mozambique). *African Journal of Ecology* **49**: 510–514.

Muassinar, D. (2015). CEPF Chimanimani Workshop report, 13-14 April 2015. Ndzou Camp, Mpunga, Manica. Micaia Foundation, Chimoio, Mozambique.

Müller. T. (1999). The distribution, classification and conservation of rainforests in Zimbabwe. In: J.R. Timberlake & S. Kativu (editors), *African Plants: Biodiversity, Taxonomy and Uses*, pp. 221–235. Proceedings of the 1997 AETFAT Congress, Harare. Royal Botanic Gardens, Kew.

Müller. T. (2006). The distribution, classification and conservation of rainforests in Eastern Zimbabwe. Occasional Publications in Biodiversity No. 19. Biodiversity Foundation for Africa, Bulawayo, Zimbabwe. Available at http://www.biodiversityfoundation.org/documents/BFA No.19_Rainforests E Zimbabwe .pdf

Mullin, L.J. (1994). History. In: J. Timberlake & P. Shaw (editors), *Chirinda Forest – A Visitors' Guide*, pp. 12–33. Zimbabwe Forestry Commission, Harare.

Ndunguru, E., Dondeyne, S. & Mulaboa, J. (2006). Illegal gold mining in the Chimanimani National Reserve: environmental and socio-economic assessment. Unpublished report, Chimanimani National Reserve, Mozambique.

Oliviera, Octávio Roza de (1973). Zimbáuès de Moçambique (Proto-história Africana). *Monumenta* **9**: 47, 54.

Parker, V. (2001). Mozambique. In: *Important Bird Areas in Africa and Associated Islands: Priority Sites for Conservation* (eds. L.D.C. Fishpool & M.I. Evans), pp. 627–638. Pisces Publications & BirdLife International, Newbury & Cambridge, UK.

Parker, V. (2005). *The Atlas of the Birds of Central Mozambique*. Endangered Wildlife Trust, Johannesburg/Avian Demography Unit, University of Cape Town, South Africa.

Peterhouse Petrean Society (accessed 2015). 1971 Peterhouse School Chimanimani expeditions. Available at http://www.petreans.co.zw/chimanimani/123-1971-chimanimani-expeditions

Phipps, J.B. & Goodier, R. (1962). A preliminary account of the plant ecology of the Chimanimani mountains. *Journal of Ecology* **50**: 291–319.

Quaile, D. (1973). Botany – December, '72 and Botany – August, 1973. December, 1972–August, 1973 Expedition. "The Corner" – Chimanimani Mountains. Rhodesian Schools Exploration Society (Mashonaland), Harare [Salisbury], Zimbabwe. pp. 24–36.

Rangeley, W.H.J. (1960). Ancient iron working on the Nyika plateau. *Nyasaland Journal* **13**: 18–20.

Rendle, A.B., Baker, E.G., Moore, S., Gepp, A. & Swynnerton, C.F.M. (1911). A contribution to our knowledge of the Flora of Gazaland. *Journal of the Linnean Society, Botany* **40**: 1–245.

República de Moçambique (1999). Lei no. 10/99 de 7 de Julho [Protected Area legislation].

República de Moçambique (2003). Decreto no. 34/2003 de 19 de Agosto [Chimanimani TFCA boundary]. *Boletim da República, 1º série*, no. 38: 394-396.

República de Moçambique (2013). Decreto no. 89/2013 de 31 de Decembro [Chimanimani TFCA revised boundary]. *Boletim da República, 1º série*, no. 104: 212-214.

Reynolds, G.W. (1966). *The Aloes of Tropical Africa and Madagascar*. Trustees of the Aloes Book Fund, Mbabane, Swaziland.

Robertson, F. (1986). A study of the conservation status of botanical reserves in Zimbabwe. *Zimbabwe Science News* **20**: 102–106.

Ryan, P.G., Cassidy, R. & Salinger, T. (1984). The Haroni–Lusitu Junction revisited. *Honeyguide* **30**: 90–91.

Schafer, J. & Bell, R. (2002). The State and community-based natural resource management: The case of the Moribane Forest Reserve, Mozambique. *Journal of Southern African Studies* **28**(2): 401–420.

Shah, T. (2016). Conservation Status of the Plants of the Chimanimani Mountains, Mozambique, based on four endemic species. Unpublished MSc dissertation, University of Reading, UK. 67 pp.

Shaw, J. (2012). First Expedition, Rhodesian Schools' Exploration Society, Chimanimani Mountains 1954. Our Rhodesian Heritage website. Available at http://rhodesianheritage.blogspot.co.uk/2012/06/first-expedition-rhodesian-schools.html

Sinclair, S. (1971). *The Story of Melsetter*. M.O. Collins, Harare [Salisbury], Zimbabwe. Available at https://archive.org/details/TheStoryOfMelsetter

Smithers, R.H.N. & Lobão Tello, J.L.P. (1976). *Check List and Atlas of the Mammals of Mozambique*. Museum Memoir No. 8. National Museums & Monuments of Rhodesia, Harare, Zimbabwe.

Soper, R. (2002). *Nyanga: Ancient fields, settlements and agricultural history in Zimbabwe*. Memoir no. 16. British Institute in Eastern Africa, London, UK.

Stagman, J.G. (1978). *An Outline of the Geology of Rhodesia*. Rhodesia Geological Survey Bulletin No. 80. Geological Survey, Harare.

Strugnell, A.M. (2006). A checklist of the spermatophytes of Mount Mulanje, Malawi. *Scripta Botanica Belgica* 34. National Botanic Garden, Meise, Belgium.

Timberlake, J.R. (1992). Chimanimani centre of plant diversity. Manuscript. National Herbarium, Harare, Zimbabwe.

Timberlake, J.R. (1994). Changes in the extent of moist forest patches in the Eastern Highlands: case studies based on aerial photographs. Research Paper No. 7. Zimbabwe Forestry Commission, Harare, Zimbabwe.

Timberlake, J.R. (1999). List of plants from the Lower Rusitu valley (Haroni, Rusitu & and Makurupini forests). Unpublished checklist. Bulawayo, Zimbabwe.

Timberlake. J.R. (2014). Mountain Gold – Conservation in the Chimanimani Mountains, Mozambique. Available at http://www.birdlife.org/worldwide/mountain-gold-E2%80%92-conservation-chimanimani-mountains-mozambique

Timberlake, J.R., Darbyshire, I., Cheek, M., Banze, A., Fijamo, V., Massunde, J., Chipanga H. and Muassinar, D. (2016). Plant conservation in communities on the Chimanimani footslopes, Mozambique. Report produced under the Darwin Initiative Award 2380. Royal Botanic Gardens, Kew, London, UK.

Timberlake, J.R. & Müller, T. (1994). Identifying and describing areas for vegetation conservation in Zimbabwe. *Strelitzia* **1**: 125–139.

Timberlake, J. & Shaw, P. [editors] (1994). *Chirinda Forest – A Visitors' Guide*. Forest Research Division, Zimbabwe Forestry Commission, Harare.

Tomlinson, R.W. (1973). The Inyanga area: an essay in regional biogeography. *University of Rhodesia Occasional Papers* **1**: 1–67.

Trueluck, T. (n.d.). Caves of Chimanimani. On Darklife: Caves and Caving in the Cape website. http://www.darklife.co.za/Caves/5.Other_areas/Zimbabwe/Chimanimani.html

Trueluck, T.F. (1994a). The formation of the Frontier Shafts area. *Bulletin of the South African Speleological Association* **35**: 58–63.

Trueluck, T.F. (1994b). The fauna of the Frontier Shafts area. *Bulletin of the South African Speleological Association* **35**: 64–65.

Van Wyk, A.E. & Smith, G.F. (2001). Chimanimani–Nyanga Centre. Chapter 10, *Regions of Floristic Endemism in Southern Africa: A review with emphasis on succulents*, pp. 140–145. Umdaus Press, Hatfield, South Africa.

Watson, R.L.A. (1969). *The Geology of the Cashel, Melsetter and Chipinga Areas*. Rhodesia Geological Survey Bulletin No. 60. Geological Survey, Harare.

Weimark, H. (1941). The groups, centres and intervals within the Cape Flora. *Lund Univ., Arssk., N.F. Avd. 2*, **37**: 5.

White, F. (1978). The Afromontane region. In: *Biogeography and Ecology of Southern Africa* (edited by M.J.A. Werger), pp. 463–513. W. Junk, The Hague, Netherlands.

White, F. (1983). *The Vegetation of Africa*. Natural Resources Research No.20. UNESCO, Paris.

Wild, H. (1964). The endemic species of the Chimanimani mountains and their significance. *Kirkia* **4**: 125–157.

Wild, H. (1968). Phytogeography of South Central Africa. *Kirkia* **6**: 197–222.

Wild, H. & Barbosa, L.A.G. (1968). Vegetation map of the Flora Zambesiaca area. M.O. Collins, Harare.

Zoological Society of London (2016). EDGE, Evolutionary Distinct and Globally Endangered. Available at 99 Cave squeaker. http://www.edgeofexistence.org/amphibians/species_info.php?id=643 (accessed August 2016).

ANNEX 1. Participants in the CEPF-funded botanical expeditions, 2014 and 2016.

April 2014
Petra Ballings, National Herbarium, Meise, Belgium
Armindo Carlos Dapaz, cook, Chimoio
Jeneen Hadj-Hammou, intern, Herbarium, Royal Botanic Gardens Kew, London
Anthony Mapaura, National Herbarium & Botanic Gardens, Harare, Zimbabwe
Hermenegildo Matimele, National Herbarium, IIAM, Maputo
Daglasse Muassinar, Micaia Foundation, Chimoio, Mozambique
Atinahama Chari Nyahedze, Chief, Nyabowa Community, Sussundenga
Robert Sevenwatch, guide, Nyabowa Community, Sussundenga
Jonathan Timberlake (team leader), Herbarium, Royal Botanic Gardens Kew, London
Bart Wursten, independent botanist, Meise, Belgium

October–November 2014
Inês Chelene, National Herbarium, IIAM, Maputo
Hercília Chipanga, Micaia Foundation, Chimoio
Armindo Carlos Dapaz, cook, Chimoio
Anthony Mapaura, National Herbarium & Botanic Gardens, Harare, Zimbabwe
João Massunde, Micaia Foundation, Nzhou Camp, Sussundenga
Daglasse Muassinar, Micaia Foundation, Chimoio
Kudakwashe Mutasa, National Herbarium & Botanic Gardens, Harare, Zimbabwe
Manuel Filimone Mawaque, guide, Zomba Community, Sussundenga
Samuel Marcopo, guide, Zomba Community, Sussundenga
Jonathan Timberlake (team leader), Herbarium, Royal Botanic Gardens Kew, London
Bart Wursten, independent botanist, Meise, Belgium

April–May 2016
Aurelio Banze, National Herbarium, IIAM, Maputo
Neil Brummitt, Dept. Botany, Natural History Museum, London
Rebat Chapwanyha, guide, Nyabowa Community, Sussundenga
Cacilda Chirindzane, Seed Bank, IIAM, Maputo
Anthony Mapaura, Research Officer, National Herbarium & Botanic Gardens, Harare
João Massunde, Micaia Foundation, Nzhou Camp, Sussundenga
Daglasse Muassinar, Projects Officer, Micaia Foundation, Chimoio
Atinahama Chari Nyahedze, Chief, Nyabowa Community, Sussundenga
Jo Osborne, Herbarium, Royal Botanic Gardens Kew, London
Robert Sevenwatch, guide, Nyabowa Community, Sussundenga
Paulo Sevenwatch, guide, Nyabowa Community, Sussundenga
Toral Shah, MSc student, University of Reading, UK
Jonathan Timberlake (team leader), Herbarium, Royal Botanic Gardens Kew, London
Kenneth Vhanda, cook, Chimoio

ANNEX 2. List of range-restricted species associated with the Chimanimani Mountains.

Grp	Family	Taxon	Endem	Localities	IUCN assessment	Threats				Notes
						rare	habitat clear.	fire	miners direct	
Di	Apiaceae	Centella obtriangularis *Cannon*	E	Chimanimani Mts, unconfirmed in Zimbabwe	VU D2	X			X	
Di	Apocynaceae	Asclepias cucullata *(Schltr.) Schltr*. subsp. scabrifolia *(S.Moore) Goyder*	MHE	Chimanimani Mts, Vumba,Tarka FR, Stapleford						
Di	Apocynaceae	Asclepias graminifolia *(Wild) Goyder*	E	Chimanimani Mts	LC	X				
Di	Apocynaceae	Aspidoglossum glabellum *Kupicha*	NE	Chimanimani Mts, Glencoe FR						
Di	Apocynaceae	Ceropegia sp. nov. near C. linearis	E	Chimanimani Mts		X				
Di	Apocynaceae	Raphionacme chimanimaniana *Venter & R.L.Verh.*	E	Chimanimani Mts, Chikukwa	EN B2ab(iii)	X	X			
Di	Asteraceae	Anisopappus paucidentatus *Wild*	E	Chimanimani Mts	LC					
Di	Asteraceae	Aster chimanimaniensis *Lippert*	E	Chimanimani Mts	DD	X				
Di	Asteraceae	Gutenbergia westii *(Wild) Wild & G.V.Pope*	NE	Chimanimani Mts, Sussundenga, Serra Macuta, Chimanimani farms, Chipinge	VU B1ab(iii)+2ab(iii)		X	X		low altitude quartzite & others
Di	Asteraceae	Helichrysum africanum *(S.Moore) Wild*	E	Chimanimani Mts	LC					
Di	Asteraceae	Helichrysum chasei *Wild*	MHE	Pungwe hills, Chimanimani town, Tsetserra						
Di	Asteraceae	Helichrysum maestum *Wild*	E	Chimanimani Mts, not yet in Mozambique		X				2 localities
Di	Asteraceae	Helichrysum moorei *Staner* (= H. spenceranum *Wild*)	E	Chimanimani Mts	LC					
Di	Asteraceae	Helichrysum rhodellum *Wild*	NE	Chimanimani Mts, Mt Pene		X				1 locality
Di	Asteraceae	Schistostephium oxylobum *S.Moore*	MHE	Chimanimani Mts, Vumba, Nyanga, Nyangani, Mt Pene, Tsetserra, Rotanda, Mutsarara	VU B1ab(iii)+2ab(iii)		X	X		
Di	Asteraceae	Senecio aetfatensis *B.Nord.*	E	Chimanimani Mts	LC	X				
Di	Asteraceae	Vernonia muelleri *Wild* subsp. muelleri	E-low	Chimanimani Mts, Makurupini			X			mostly low altitude
Di	Asteraceae	Vernonia nepetifolia *Wild*	E	Chimanimani Mts						only 3 georeferenced localities
Di	Balsaminaceae	Impatiens salpinx *Schulze & Launert*	E	Chimanimani Mts	VU D2		X		X	
Di	Campanulaceae	Cyphia alba *N.E.Br.*	MHE	Chimanimani Mts, Mutare, Nyanga	LC					
Di	Campanulaceae	Lobelia cobaltica *S.Moore*	E	Chimanimani Mts	LC					
Di	Campanulaceae	Wahlenbergia subaphylla *(Baker) Thulin* subsp. scoparia *(Wild) Thulin*	MHE	Chimanimani Mts, Chimanimani farms (Pork Pie), Musapa, Vumba						
Di	Caryophyllaceae	Dianthus chimanimaniensis *S.S.Hooper*	E	Chimanimani Mts, Musapa Gap	VU D2	X	X			

Grp	Family	Taxon	Endem	Localities	IUCN assessment	Threats				Notes
						rare	habitat clear.	fire	miners direct	
Di	Crassulaceae	Crassula alticola *R.Fern.*	MHE	Chimanimani Mts, Tsetserra, Nyanga, Umvumvumvu R., Vumba, Rukotso, Banti, Nyangani, Gorongosa	LC					
Di	Crassulaceae	Kalanchoe velutina *Britten* subsp. chimanimaniensis *(R.Fern.) R.Fern.*	E	Chimanimani Mts						
Di	Ebenaceae	Diospyros sp. 2 of FZ	NE	Chimanimani Mts, Serra Macuta, Haroni-Rusitu		X				
Di	Ericaceae	Erica lanceolifera *S.Moore*	NE	Chimanimani Mts, Chimanimani farms, Martin FR, Tarka FR, Mt Pene, Himalaya	VU B1ab(iii)+2ab(iii)		X			
Di	Ericaceae	Erica pleiotricha *S.Moore* var. blaerioides *(Wild) R.Ross*	NE	Chimanimani Mts, Chimanimani farms, Martin FR, Tandai, Mt Pene, Mutsarara	NT		X			
Di	Ericaceae	Erica pleiotricha *S.Moore* var. pleiotricha	NE	Chimanimani Mts, Mt Pene	VU D2			X		
Di	Ericaceae	Erica wildii *Brenan*	E	Chimanimani Mts including The Corner	LC					
Di	Euphorbiaceae	Euphorbia crebrifolia *S.Carter*	MHE	Chimanimani Mts, Nyangani	LC					
Di	Euphorbiaceae	Euphorbia rugosiflora *L.C.Leach*	E	Chimanimani Mts, The Corner	EN D	X				small population
Di	Gesneriaceae	Streptocarpus acicularis *I.Darbysh. & Massingue*	E-low	Chimanimani foothills (southern)	CR B2ab(iii)	X	X			non-montane; single locality
Di	Gesneriaceae	Streptocarpus grandis *N.E.Br.* subsp. septentrionalis *Hilliard & B.L.Burtt*	NE	Chimanimani Mts, Chimanimani farms, Tarka FR, Mt Pene, Haroni/Rusitu						not always on sandstone; by rivers lower down
Di	Gesneriaceae	Streptocarpus hirticapsa *B.L.Burtt*	MHE	Chimanimani Mts, Mutsarara, Vumba	VU D2	X			X	
Di	Gesneriaceae	Streptocarpus michelmorei *B.L.Burtt*	NE	Chimanimani Mts, Busi R. near Gogoi, Ngorima, Mt Selinda						
Di	Gesneriaceae	Streptocarpus montis-bingae *Hilliard & B.L.Burtt*	E	Chimanimani Mts	DD	X				
Di	Gesneriaceae	Streptocarpus sp. nov. near S. grandis	E	Chimanimani Mts		X				discovered 2014
Di	Lamiaceae	Aeollanthus viscosus *Ryding*	E	Chimanimani Mts	LC					
Di	Lamiaceae	Plectranthus caudatus *S.Moore*	NE	Chimanimani Mts, Namuli	VU D2		X			Namuli plant a new species?
Di	Lamiaceae	Plectranthus chimanimanensis *S.Moore*	MHE	Chimanimani Mts, Mt Pene, Vumba, Nyanga, Mtarazi, Banti FR, Gorongosa	LC					
Di	Lamiaceae	Plectranthus sessilifolius *A.J.Paton*	MHE	Chimanimani Mts, Rotunda, Nyanga, Himalaya						
Di	Lamiaceae	Syncolostemon flabellifolius (S.Moore) A.J.Paton	E	Chimanimani Mts	LC					also lower altitude
Di	Lamiaceae	Syncolostemon oritrephes *(Wild) D.F.Otieno*	E	Chimanimani Mts	VU D2	X		X		schist endemic
Di	Lamiaceae	Syncolostemon ornatus *(S.Moore) D.F.Otieno*	NE	Chimanimani Mts, Chimanimani farms, Mt Pene, Tarka FR, Martin FR, Mutsarara	VU B1ab(iii)+2ab(iii)		X			

Grp	Family	Taxon	Endem	Localities	IUCN assessment	Threats				Notes
						rare	habitat clear.	fire	miners direct	
Di	Lamiaceae	Syncolostemon sp. nov. near S. teucrifolius	E	Chimanimani Mts		X				single locality; only 2014
Di	Leguminosae: Papilionoideae	Aeschynomene aphylla *Wild*	E	Chimanimani Mts	VU D2				X	
Di	Leguminosae: Papilionoideae	Aeschynomene chimanimaniensis *Verdc.*	E	Chimanimani Mts	LC					
Di	Leguminosae: Papilionoideae	Aeschynomene gazensis *Baker f.*	UMK	Chimanimani Mts, Chimanimani farms, Tarka FR, Mt Pene	EN B1ab(iii)+B2ab(iii)		X			mostly non-montane
Di	Leguminosae: Papilionoideae	Aeschynomene grandistipulata *Harms*	E	Chimanimani Mts	LC					
Di	Leguminosae: Papilionoideae	Crotalaria insignis *Polhill*	MHE	Chimanimani Mts, Chimanimani farms, Chisengu FR, Tarka FR, Mt Pene, Tsetserra, Penhalonga	VU B1ab(iii)+2ab(iii)		X	X		
Di	Leguminosae: Papilionoideae	Crotalaria phylicoides *Wild*	E	Chimanimani Mts	LC					
Di	Leguminosae: Papilionoideae	Indigofera cecilii *N.E.Br.*	MHE	Chimanimani Mts, Chimanimani farms, Mt Dombe, Nyanga, Chirinda, Gorongosa	NT		X			
Di	Leguminosae: Papilionoideae	Indigofera chimanimaniensis *Schrire*	UMK	Chimanimani farms, Chikukwa	EN B2ab(iii)	X	X			non-montane
Di	Leguminosae: Papilionoideae	Indigofera sp. nov. near I. chimanimaniensis	E	Chimanimani Mts		X				
Di	Leguminosae: Papilionoideae	Kotschya sp. A of FZ	UMK	Chimanimani farms, Mt Pene, Tarka FR						not montane or in Chimanimani Mts
Di	Leguminosae: Papilionoideae	Pearsonia mesopontica *Polhill*	NE	Chimanimani Mts, Pork Pie	LC					
Di	Leguminosae: Papilionoideae	Rhynchosia chimanimaniensis *Verdc.*	NE	Chimanimani Mts, Chimanimani farms, Mt Pene, Rotanda	EN B1ab(iii)+B2ab(iii)		X			
Di	Leguminosae: Papilionoideae	Rhynchosia stipata *Meikle*	E	Chimanimani Mts	LC					
Di	Leguminosae: Papilionoideae	Rhynchosia swynnertonii *Baker f.*	MHE	Chimanimani farms, S Chimanimani area, Nyanga Downs, Nyanga, Serra Choa, Stapleford, Penhalonga, Odzani, Vumba, Chirinda, Himalaya	LC					upland, but not in Chimanimani Mts
Di	Leguminosae: Papilionoideae	Tephrosia chimanimaniana *Brummitt*	NE	Chimanimani Mts, Serra Macuta	LC					
Di	Leguminosae: Papilionoideae	Tephrosia longipes *Meisn.* var. drummondii *(Brummitt) Brummitt*	NE	Chimanimani Mts, Tarka FR, Glencoe FR, Mt Pene						

Grp	Family	Taxon	Endem	Localities	IUCN assessment	Threats				Notes
						rare	habitat clear.	fire	miners direct	
Di	Leguminosae: Papilionoideae	Tephrosia longipes *Meisn.* var. swynnertonii *(Baker f.) Brummitt*	UMK	Chimanimani Mts, Tarka FR, Cashel, Mutasa, Haroni/Rusitu, Chirinda						
Di	Leguminosae: Papilionoideae	Tephrosia praecana *Brummitt*	UMK	Chimanimani farms, Mt Pene, Tarka FR, Martin FR, Mt Pene, Mt Chirosa (Mavita)	VU B1ab(iii)+2ab(iii)		X			
Di	Linderniaceae	Crepidorhopalon near C. whytei (= Lindernia flava)	E-low	Maronga foothills						low alttude wetlands
Di	Melastomataceae	Dissotis pulchra *A.& R.Fern.*	E	Chimanimani Mts, Mukurupini	VU D2				X	
Di	Melastomataceae	Dissotis swynnertonii *(Baker f.) A.& R.Fern.*	E	Chimanimani Mts	VU D2				X	
Di	Moraceae	Ficus muelleriana *C.C.Berg*	E-low	Chimanimani Mts	EN B1ab(iii)+2ab(iii)	X		X		quartz, lower altitude
Di	Myricaceae	Morella chimanimaniana *Verdc.& Polhill*	E	Chimanimani Mts				X		schist endemic. Awaiting reassessment
Di	Oleaceae	Olea chimanimani *Kupicha*	E	Chimanimani Mts	LC					
Di	Orobanchaceae	Buchnera chimanimaniensis *Philcox*	NE	Chimanimani Mts, Corner, Chimanimani farms, Martin FR, Himalaya, Chirinda, Chipinge	LC		X			
Di	Orobanchaceae	Buchnera subglabra *Philcox*	E	Chimanimani Mts	VU D2				X	
Di	Orobanchaceae	Buchnera wildii *Philcox*	MHE	Chimanimani farms, Mt Pene, Mutarara, Pork Pie, Tarka FR, Himalaya, Nyangani, (Nyika?)	NT		X			
Di	Passifloraceae	Basananthe parvifolia *(Baker f.) W.J.de Wilde*	UMK	Musapa, Chimanimani farms, Mt Pene, Tarka FR, Tandai, (Mutare), Chipinge area			X			
Di	Penaeaceae	Olinia subsp. nov. near O. vanguerioides	E	Chimanimani Mts		X				awaiting assessment
Di	Peraceae	Clutia punctata *Wild*	E	Chimanimani Mts	LC	X				
Di	Peraceae	Clutia sessilifolia *Radcl.-Sm.*	E	Chimanimani Mts	LC	X				
Di	Phyllanthaceae	Phyllanthus bernierianus *Müll.Arg.* var. glaber *Radcl.-Sm.*	E	Chimanimani Mts, Makurupini Falls						
Di	Proteaceae	Faurea rubriflora *Marner*	MHE	Eastern Highlands. Mutasa, Chimanimani, Nyanga, Vumba						
Di	Proteaceae	Leucospermum saxosum *S.Moore*	(NE)	Chimanimani Mts, Martin FR; also Mpumalanga (SA)						has been regarded as endemic in past; now grouped with specimens from Drakensberg Mts
Di	Proteaceae	Protea caffra *Meisn.* subsp. gazensis *(Beard) Chisumpa & Brummitt*	MHE	Chimanimani Mts, Chimanimani farms, Pork Pie, Tsetserra, Himalaya, Tandai, Serra Choa, Banti FR, Mutare, Stapleford, Nyangani, Gorongosa						
Di	Proteaceae	Protea enervis *Wild*	E	Chimanimani Mts	VU D2	X				

Grp	Family	Taxon	Endem	Localities	IUCN assessment	Threats				Notes
						rare	habitat clear.	fire	miners direct	
Di	Rubiaceae	Anthospermum ammanioides *S.Moore*	MHE	Chimanimani Mts, Chimanimani farms, Vumba, Stapleford, Nyangani, Worlds View, Pungwe View, Serra Choa	LC					
Di	Rubiaceae	Anthospermum vallicola *S.Moore*	MHE	Chimanimani Mts, Mt Pene, Vumba, Nyangani, Nyanga, Gorongosa	LC					
Di	Rubiaceae	Canthium oligocarpum *Hiern* subsp. angustifolium *Bridson*	MHE	Chimanimani Mts, Chimanimani farms, Mt Pene, Nyangani, Nyanga, Gorongosa						
Di	Rubiaceae	Empogona sp. nov. near E. congesta	E	Chimanimani Mts		X				
Di	Rubiaceae	Oldenlandia cana *Bremek.*	E	Chimanimani Mts	LC	X				
Di	Rubiaceae	Otiophora inyangana *N.E.Br.* subsp. parvifolia *(Verdc.) Puff*	E	Chimanimani Mts						
Di	Rubiaceae	Otiophora lanceolata *Verdc.*	E-low	Chimanimani Mts	VU B1ab(iii)+2ab(iii)			X		mainly low altitude quartzite
Di	Rubiaceae	Rytigynia sp. D of FZ	E	Chimanimani Mts						
Di	Rubiaceae	Sericanthe sp. B (Chimanimani taxon) of FZ	NE	Chimanimani Mts, The Corner, Tarka FR, Makurupini R.			X	X		
Di	Rubiaceae	Tricalysia coriacea *(Benth.) Hiern* subsp. angustifolia *(J.G.Garcia) Robbr.*	MHE	Chimanimani farms, The Corner, Musapa gap, Makurupini R, Honde valley, Pungwe R, Gorongosa						not montane
Di	Rutaceae	Vepris drummondii *Mendonça*	NE-low	Mukurupini, Maronga, Haroni/Rusitu, Mt Pene, Tarka FR	VU B1ab(iii)+2ab(iii)		X			
Di	Santalaceae	Thesium bundiense *Hilliard*	E	Chimanimani Mts	DD	X				
Di	Santalaceae	Thesium chimanimaniense *Brenan*	E	Chimanimani Mts	LC					
Di	Santalaceae	Thesium dolichomeres *Brenan*	E	Chimanimani Mts, Martin FR	LC					
Di	Santalaceae	Thesium pygmeum *Hilliard*	E	Chimanimani Mts	LC	X				
Di	Sapotaceae	Synsepalum sp. near S. kaessneri	E-low	Chimanimani foothills						
Di	Scrophulariaceae	Selago anatrichota *Hilliard*	E	Chimanimani Mts	LC					
Di	Selaginaceae	Selago goetzei *Rolfe* subsp. ambigua *Hilliard*	MHE	Chimanimani Mts, Chimanimani farms, Mt Pene, Vumba, Stapleford, Nyanga, Nyangani, Mtarazi Falls, Pungwe View						
Di	Thymelaeaceae	Struthiola montana *B.Peterson*	E	Chimanimani Mts	DD	X				2 collections with very different habitat
Mo	Amaryllidaceae	Cryptostephanus vansonii *I.Verd.*	MHE	Mabu, Himalaya, Chimanimani Mts, Tarka, Vumba						also known from Mt Mabu
Mo	Asparagaceae	Asparagus chimanimaniensis *Sebsebe*	E	Chimanimani Mts, Chikukwa	LC					
Mo	Asparagaceae	Chlorophytum pygmaeum *(Weim.) Kativu* subsp. rhodesianum *(Rendle) Kativu*	NE	Chimanimani Mts, Chimanimani town			X			

Grp	Family	Taxon	Endem	Localities	IUCN assessment	Threats				Notes
						rare	habitat clear.	fire	miners direct	
Mo	Asparagaceae	Eriospermum mackenii *Hook.f.* subsp. phippsii *(Wild) P.C.Perry*	E	Chimanimani Mts, Musapa Gap, Martin FR, Chikukwa						
Mo	Asparagaceae	Sansevieria pedicellata *la Croix*	E	Chimanimani Mts (Musapa)		X				
Mo	Asphodelaceae	Aloe ballii *Reynolds* var. ballii	E-low	Haroni/Rusitu	VU D2	X		X		
Mo	Asphodelaceae	Aloe ballii *Reynolds* var. makurupiniensis *A.Ellert*	E-low	Mukurupini	VU D2	X		X		
Mo	Asphodelaceae	Aloe hazeliana *Reynolds* var. hazeliana	E	Chimanimani Mts	LC					not sure if different
Mo	Asphodelaceae	Aloe hazeliana *Reynolds* var. howmanii *(Reynolds) S.Carter*	E	Chimanimani Mts, The Corner	LC					not sure if different
Mo	Asphodelaceae	Aloe munchii *Christian*	E	Chimanimani Mts	LC	X				
Mo	Asphodelaceae	Aloe musapana *Reynolds*	NE	Chimanimani Mts, Musapa, Cashel	VU D2	X	X			
Mo	Asphodelaceae	Aloe plowesii *Reynolds*	E	Chimanimani Mts	VU D2		X			
Mo	Asphodelaceae	Aloe swynnertonii Rendle	MHE	Chimanimani Mts, Honde Valley, Gorongosa						
Mo	Asphodelaceae	Aloe wildii *(Reynolds) Reynolds*	E	Chimanimani Mts, The Corner	LC					
Mo	Eriocaulaceae	Mesanthemum africanum *Moldenke*	E	Chimanimani Mts, Martin FR, Makurupini	LC					also lower altitude
Mo	Iridaceae	Dierama plowesii *Hilliard*	MHE	Chimanimani Mts, Chimanimani farms, Mutare, Sheba	VU B1ab(ii)+2ab(iii)		X			
Mo	Iridaceae	Gladiolus juncifolius *Goldblatt*	E	Chimanimani Mts (no Mozambique record)		X				
Mo	Iridaceae	Hesperantha ballii *Wild*	E	Chimanimani Mts	LC	X				
Mo	Orchidaceae	Angraecum chimanimaniense *G.Will.*	E	Chimanimani Mts		X				
Mo	Orchidaceae	Bulbophyllum ballii *P.J.Cribb*	MHE	Chimanimani Mts, Chimanimani farms, Malema, Mutzingazi, Vumba, Pungwe Falls, Haroni gorge, Mabu						also known from Mt Mabu
Mo	Orchidaceae	Cynorkis anisoloba *Summerh.*	MHE	Chimanimani, Nyanga						
Mo	Orchidaceae	Disa chimanimaniensis *(H.P.Linder) H.P.Linder*	E	Chimanimani Mts						
Mo	Orchidaceae	Liparis chimanimaniensis *G.Will.*	MHE	Chimanimani Mts, Stapleford, (Mulanje?)		X				Malawi specimen probably mis-id
Mo	Orchidaceae	Neobolusia ciliata *Summerh.*	MHE	Chimanimani Mts, Mutsarara, Pungwe Falls, Makoni/Rusape			X			
Mo	Orchidaceae	Oligophyton drummondii *H.P.Linder & G.Will.*	E	Chimanimani Mts		X				
Mo	Orchidaceae	Polystachya subumbellata *P.J.Cribb & Podzorski*	MHE	Chimanimani Mts, Himalaya, Vumba						
Mo	Orchidaceae	Polystachya valentina *la Croix & P.J.Cribb*	MHE	Chimanimani Mts, Banti FR, Chimoio						

Grp	Family	Taxon	Endem	Localities	IUCN assessment	Threats				Notes
						rare	habitat clear.	fire	miners direct	
Mo	Orchidaceae	Satyrium flavum *la Croix*	MHE	Chimanimani Mts, Nyangani						
Mo	Orchidaceae	Satyrium hallackii *Bolus* var. ballii *(van der Niet & P.J.Cribb) van der Niet & P.J.Cribb*	MHE	Chimanimani farms, Tandai, Odzani, Troutbeck						non-montane
Mo	Orchidaceae	Satyrium mirum *Summerh.*	MHE	Chimanimani farms, Himalaya		X				non-montane
Mo	Orchidaceae	Schizochilus calcaratus *P.J.Cribb & la Croix*	E	Chimanimani Mts		X				
Mo	Orchidaceae	Schizochilus lepidus *Summerh.*	NE	Chimanimani Mts, Tsetserra, Himalaya						
Mo	Poaceae	Danthoniopsis chimanimaniensis *(J.B.Phipps) Clayton*	E	Chimanimani Mts, Martin FR, Haroni/Rusitu	EN B1ab(iii)+2ab(iii)				X	
Mo	Poaceae	Eragrostis desolata *Launert*	E	Chimanimani Mts	LC					
Mo	Restionaceae	Platycaulos (Restio) quartziticola *(H.P.Linder) H.P.Linder & C.R.Hardy*	E	Chimanimani Mts	LC					
Mo	Velloziaceae	Xerophyta argentea *(Wild) L.B.Smith & Ayensu*	E	Chimanimani Mts, Martin FR, Rotanda	LC				X	
Mo	Xyridaceae	Xyris asterotricha *Lock*	E	Chimanimani Mts	VU D2	X			X	
Mo	Xyridaceae	Xyris sp. ?nov.	E	Chimanimani Mts		X				single record
Gm	Zamiaceae	Encephalartos chimanimaniensis *R.A.Dyer & I.Verd.*	UMK	Makurupini, Espungabera, Chirinda, Chipinge	[1] EN B1ab(i,ii,iv,v) +2ab(i,ii,iv,v), C1	X	X			extinct in Zimbabwe (Chipinge?); good population in lowland S Chimanimani

Notes: Grp: Di = dicotyledon; Mo = monocotyledon; Gm = gymnosperm
Endemism: E = endemic, confined solely to Chimanimani Mts
NE = near-endemic, i.e. not confined to Chimanimani Mts but also in adjacent areas
MHE = Manica Highlands endemic
UMK = Umkondo sandstone endemic (non-Chimanimani Mts)
Assessment: [1] Assessment from IUCN Red List website

ANNEX 3. Georeferenced localities on or related to the Chimanimani Mountains.

Country	**Locality**	**DD.MM.SS**		**DD.DDDD**		**Alt. (m)**	**Notes**
		South	East	South	East		
Zim	Bailey's Folly	19 47 29	33 00 02	-19.791370	33.000597	1560	
Zim	Banana Grove	19 48 24	33 00 05	-19.806639	33.001386	1502	
Zim	BB65A	19 39 04	32 58 33	-19.651023	32.975791	1817	Boundary Beacon, The Corner
Zim	BB68	19 43 04	32 57 22	-19.717756	32.956191	1095	Boundary Beacon
Zim	BB70	19 44 57	33 00 50	-19.749262	33.014028	1980	Boundary Beacon
Zim	BB71A	19 48 38	33 02 53	-19.810588	33.048087	2270	Boundary Beacon
Zim	BB73	19 57 22	33 01 32	-19.956179	33.025465	1624	Boundary Beacon
Zim	Biriwiri Mission	19 48 25	32 42 20	-19.807069	32.705490	1052	
Zim	Bridal Veil Falls	19 47 27	32 50 56	-19.790717	32.849023	1492	
Zim	Bundi River, leaving Bundi Plain	19 47 19	33 01 42	-19.788608	33.028239	1603	where Bundi River leaves Bundi plain
Zim	Bundi Plain	19 46 48	33 01 28	-19.780117	33.024380	1614	central point of northern part
Zim	Bundi Plain, upper	19 46 13	33 01 06	-19.770141	33.018260	1650	upper part below Mt Peza
Zim	Bundi River	19 47 08	33 01 28	-19.785541	33.024468	1613	
Zim	Bundi River source	19 45 24	33 01 17	-19.756568	33.021382	1805	
Zim	Bundi River waterfalls	19 45 54	19 45 54	-19.765127	33.020337	1682	
Zim	Bundi Valley	19 48 11	33 01 47	-19.802966	33.029741	1485	lower Bundi valley
Zim	Cambridge airfield	19 48 43	32 44 30	-19.811959	32.741634	1709	Chimanimani airfield towards Biriwiri Mission
Moz	Camp Portage	19 45 55	33 05 52	-19.765176	33.097760	1660	Campsite by Martin's Falls
Zim	Chambuka River	19 59 06	32 55 54	-19.985115	32.931607	1011	near Tarka Forest
Moz	Chief Zomba	19 52 14	33 15 31	-19.870659	33.258630	174	Chief Zomba's village
Zim	Chikukwa	19 42 22	32 55 48	-19.706194	32.929937	1211	Communal Land, next to Martin Forest Land/ The Corner
Zim	Chimanimani Hotel	19 48 11	32 52 21	-19.803143	32.872507	1520	
Zim	Chirawondi	19 41 26	32 59 08	-19.690524	32.985676	1775	peak on border
Zim	Chisengu Forest Land	19 54 57	32 52 57	-19.915862	32.882553	1340	Chisengu HQ
Zim	Dead Cow Camp	19 47 48	32 59 29	-19.796775	32.991257	1263	
Zim	Dead Cow gulch	19 47 49	32 59 49	-19.796963	32.997072	1344	
Zim	Digby's Cave	19 47 24	33 01 52	-19.790029	33.031060	1531	
Zim	Digby's Falls & Pool	19 47 21	33 01 46	-19.789204	33.029334	1560	
Zim	Dragon's Tooth Rock	19 56 17	33 01 43	-19.938008	33.028612	1673	peak on border
Zim	Eland Sanctuary	19 47 33	32 51 46	-19.792592	32.862757	1766	Chimanimani Eland Sanctuary
Moz	Elephant Lake	19 49 23	33 09 20	-19.823014	33.155684	1104	lake on Rio Mufomodzi
Zim	Engwa Farm	19 22 14	32 46 46	-19.370639	32.779547	1873	farm by Himalayas/ Tsetserra
Zim	Everglades Farm	19 47 46	32 50 05	-19.796171	32.834709	1407	farm by Chimanimani village
Zim	Forest Glade Farm	19 59 18	32 52 11	-19.988379	32.869705	1373	farm by Tarka Forest Land
Moz	Gossamer Falls	19 53 10	33 08 41	-19.886027	33.144670	490	waterfalls on Rio Mufomodzi
Zim	Grass Fell West	19 29 10	32 50 25	-19.486088	32.840370	1674	farm near Cashel
Zim	Greenmount Farm	19 50 56	32 52 55	-19.848794	32.881990	1350	farm near Chimanimani village
Zim	Hadenge Pass	19 46 17	33 00 08	-19.771256	33.002269	1360	gully up to Bundi plain
Zim	Haroni Botanic Reserve	20 01 35	33 01 31	-20.026493	33.025366	337	
Zim	Haroni Gorge	20 00 14	33 00 49	-20.003839	33.013541	545	on lower Haroni River near Makurupini
Zim	Haroni River, upper	19 47 16	32 58 23	-19.787644	32.973092	1050	upper reaches of Haroni, before going into gorges
Zim	Haroni River, upper peaks	19 50 02	33 00 13	-19.833927	33.003685	1470	small peak above upper Haroni River
Zim	Hidden Valley	19 51 25	33 00 45	-19.856989	33.012595	1460	below Southern Lakes

Country	**Locality**	**DD.MM.SS**		**DD.DDDD**		**Alt. (m)**	**Notes**
		South	East	South	East		
Zim	Himalayas	19 24 34	32 46 31	-19.409319	32.775321	2095	plateau south of Tsetserra
Zim	Junction Gate	19 30 25	32 31 53	-19.506831	32.531420	672	road junction above Chimanimani village
Zim	Kasipiti	19 59 46	32 47 33	-19.995987	32.792473	1167	Farm west of Tarka Forest Land
Zim	Long Gully	19 47 47	33 00 07	-19.796502	33.002033	1528	top of Dead Cow gulch?
Zim	Long Gully, top end	19 47 44	33 00 20	-19.795572	33.005459	1680	
Moz	Ma-Esese / Ma SS	19 52 12	33 03 49	-19.870054	33.063728	1425	area of schist grassland by The Saddle
Moz	Mahoendzi	19 58 02	33 02 14	-19.967152	33.037300	1656	peak in S Chimanimani, Mozambique
Zim	Makurupini Forest	20 01 01	33 01 14	-20.016923	33.020442	380	inside Chim Nat. Park
Zim	Makurupini River	20 00 43	33 01 36	-20.012081	33.026586	400	[see also Mukurupini]
Zim	Martin Forest Land II	19 44 15	32 56 40	-19.737505	32.944487	1280	southern portion by Chimanimani village
Zim	Martin Forest Land, The Corner	19 41 34	32 56 54	-19.692677	32.948430	1433	section in The Corner, edge of National Park
Moz	Martin's Falls	19 46 51	33 07 05	-19.780748	33.117977	1500	Martin's or Mufomodzi Falls
Zim	Melsetter Research Station	19 47 39	32 53 07	-19.794070	32.885192	1560	now closed, previously Melsetter Pasture Research Station on Lindley North farm
Zim	Mermaid's Grotto	19 58 53	32 52 57	-19.981500	32.882628	1513	farm and forest by Mt Pene, near Tarka Forest Land
Moz	Mevumodzi River						See Mufomodzi
Zim	Mountain Hut	19 47 03	33 01 10	-19.784118	33.019467	1700	
Zim	Mt Binga	19 46 35	33 03 43	-19.776479	33.062342	2437	summit cairn
Zim	Mt Binga, lower S slopes	19 47 36	33 02 14	-19.793333	33.037257	1680	lower slopes of Point 71, below Turret Towers
Moz	Mt Binga, NE slope	19 46 30	33 03 54	-19.775043	33.065050	2372	NE slopes of Mt Binga, Point 71
Zim	Mt Dombe	19 46 19	33 02 18	-19.771947	33.038216	2188	also called Uncontoured Peak
Moz	Mt Huco	19 40 14	33 08 26	-19.670529	33.140491	1654	NE corner of Chim range
Moz	Mt Massasse	19 44 11	33 06 50	-19.736474	33.113973	2096	NE corner of Chim range
Moz	Mt Messurussero	19 45 02	33 01 53	-19.750419	33.031457	1964	Near Mt Binga
Moz	Mt Nhamabombe	19 42 04	33 06 34	-19.701248	33.109339	1860	NE corner of Chim range
Moz	Mt Nhamedimo	19 44 17	33 04 54	-19.738020	33.081569	2144	N end of Chim range
Zim	Mt Nyangoma	19 45 12	32 59 33	-19.753227	32.992631	1890	near Mt Peza
Zim	Mt Pene	19 58 45	32 53 40	-19.979263	32.894543	1643	adjacent to Tarka Forest Land
Zim	Mt Peza	19 45 07	33 00 26	-19.751863	33.007094	2152	Mt Peza or Ben Nevis; BB69E
Zim	Mt Peza, SE slopes	19 45 35	33 00 55	-19.759719	33.015344	1820	
Moz	Mufomodzi gorge	19 48 34	33 08 24	-19.809333	33.139944	1237	sandstone cliffs above Rio Mufomodzi gorge
Moz	Mufomodzi River tributary	19 50 42	33 07 19	-19.844883	33.122022	950	side tributary of Rio Mufomodzi
Moz	Mukurupini Falls	19 59 59	33 01 55	-19.999794	33.032007	867	also Makurupini or Macurupini
Zim	Musapa Gap	19 43 10	32 57 20	-19.719425	32.955581	1043	where Musapa river enters Mozambique
Zim	Musapa Mt	19 41 12	32 51 01	-19.686565	32.850388	2144	Musapa Mt, on border by BB59B
Zim	Mutambara area	19 32 10	32 40 13	-19.536246	32.670301	1010	
Zim	Mutzarara Farm	19 58 10	32 48 04	-19.969531	32.801187	1634	or Mutsarara
Zim	Mutzingazi River	19 59 32	32 52 22	-19.992318	32.872774	1140	

Country	**Locality**	**DD.MM.SS**		**DD.DDDD**		**Alt. (m)**	**Notes**
		South	East	South	East		
Zim	National Parks HQ	19 47 20	32 59 38	-19.788805	32.993923	1313	National Parks offices + campsite
Moz	Nhamadze River headwaters	19 45 40	33 02 55	-19.761015	33.048561	1450	in Mozambique, below Skeleton Pass
Moz	Nyabowa camp	19 42 08	33 01 35	-19.702091	33.026367	900	Ecocamp by Nyabowa village (TFCA)
Zim	Nyahodi River bridge	19 51 01	32 47 50	-19.850376	32.797315	1160	along Chim-Skyline road
Moz	Nzou Camp	19 44 01	33 20 15	-19.733653	33.337517	610	in Moribane Forest, Mpunga community
Zim	Orange Grove Drive	19 48 46	32 54 28	-19.812801	32.907902	1400	road from Chimanimani village to Chisengu
Zim	Outward Bound	19 46 11	32 58 58	-19.769735	32.982840	1132	Outward Bound Mountain School
Zim	Paradise Pool	19 47 21	33 02 06	-19.789206	33.034871	1540	near Digby's Cave, tributary of upper Bundi
Zim	Peterhouse Pool	19 47 52	33 01 55	-19.797706	33.032017	1500	Bundi valley
Moz	Poachers Cave	19 51 32	33 04 58	-19.858788	33.082813	1430	in forest patch in Mozambique
Zim	Pork Pie Hill	19 47 13	32 52 26	-19.786865	32.873983	1970	or Nyamzure Hill
Zim	Ragon Falls	19 52 02	33 01 37	-19.867149	33.026981	1226	Ragon (or Dragon) Falls, on Bundi River
Zim	Red Wall Cave	19 45 47	33 01 25	-19.763096	33.023601	1720	or Red Cave, above upper Bundi River
Moz	Rio Mussapa crossing	19 42 21	33 01 31	-19.705870	33.025371	712	river crossing by Nyabowa village
Moz	Rio Nyahedzi camp	19 45 01	33 03 24	-19.750159	33.056737	1217	overnight camp on path up from Nyabowa village
Moz	Rotanda	19 31 37	32 53 03	-19.526963	32.884185	1420	In Mozambique
Zim	Rusitu Botanic Reserve	20 01 28	32 59 34	-20.024496	32.992742	492	
Zim	Sawerombi road	19 47 01	32 50 50	-19.783693	32.847257	1630	road above Chimanimani village
Moz	Serra Mocuta	19 28 35	33 07 19	-19.476404	33.121811	1373	
Zim	Skeleton Pass	19 45 52	33 02 08	-19.764307	33.035498	1724	
Zim	Skyline junction	19 52 54	32 44 20	-19.881612	32.738969	1650	road up from Chimanimani village
Zim	Southern Lakes	19 51 00	33 01 50	-19.850085	33.030597	1408	pools in Bundi River
Moz	St Georges Cave	19 52 08	33 03 12	-19.868913	33.053450	1460	used by 1970s school expeditions
Zim	Stonehenge	19 47 02	33 00 07	-19.783866	33.001866	1700	uncertain locality; possibly general N Chim plateau
Zim	Tandai Falls	19 35 07	32 48 05	-19.585256	32.801293	1340	on Chimanimani-Cashel road
Zim	Tandai Forest Land	19 36 19	32 48 21	-19.605415	32.805960	1405	
Zim	Tank Nek	19 39 31	32 49 52	-19.658578	32.831002	1690	farm on Cashel road
Zim	Tarka Forest Land	19 57 51	32 57 37	-19.964226	32.960212	1300	central point of northern part
Zim	Terry's Cave	19 49 30	33 02 01	-19.825040	33.033509	1530	
Zim	Tessa's Pool	19 46 11	32 58 44	-19.769667	32.978874	1094	
Zim	The Aerodrome	19 48 16	33 01 11	-19.804480	33.019720	1690	or Airstrip. Broad smooth grassy area
Zim	The Corner	19 41 22	32 57 53	-19.689545	32.964823	1300	central point of quartzite area
Zim	The Needle	19 47 31	33 00 47	-19.791938	33.013094	1744	
Zim	The Saddle	19 51 23	33 02 42	-19.856281	33.045123	1512	pass over border into Mozambique
Zim	Third Range	19 52 40	33 02 29	-19.877887	33.041279	1700	third ridge from Zimbabwe, forming border
Zim	Tilbury airfield	19 54 31	32 58 07	-19.908701	32.968744	970	
Zim	Tilbury, Timbiri River	19 56 00	32 58 46	-19.933272	32.979467	925	Timbiri River on edge of Tilbury Estate

Country	**Locality**	**DD.MM.SS**		**DD.DDDD**		**Alt. (m)**	**Notes**
		South	East	South	East		
Zim	Timbiri Falls	19 58 01	32 59 06	-19.966991	32.984926	840	on Timbiri River
Zim	Timbiri Hills	19 55 23	32 59 28	-19.923109	32.991159	1030	hills above Timbiri Valley
Moz	Triple Falls	19 46 32	33 08 00	-19.775420	33.133292	1280	waterfalls on unnamed tributary below Tucker's Falls
Moz	Tsetserra	19 23 11	32 47 52	-19.386415	32.797706	2228	Tsetserra Mountain, by old commercial farm
Moz	Tucker's Falls	19 46 17	33 07 55	-19.771319	33.132025	1411	tall waterfall on tributary of Rio Mufomodzi
Zim	Turret Towers	19 47 49	33 02 50	-19.796825	33.047239	2362	Turret Towers peak / Mawenje
Zim	Umvumvumvu River, upper	19 32 29	32 44 10	-19.541473	32.736190	1070	upper reaches of Umvumvumvu River by Cashel
Moz	World Challenge Camp	19 45 55	33 05 20	-19.765279	33.088971	1675	camp used by 3rd CEPF expedition