Vegetation Survey and Management Recommendation for Mount Gorongosa

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1. Introduction

Gorongosa National Park, like all formally protected conservation areas in Mozambique, was strongly compromised during the independence war and the subsequent period of civil war. The Carr Foundation is assisting the Mozambique Department of National Parks (DNFFB) in restoring the Park, so that it again becomes an important tourist attraction and vital conservation area.

The wetlands are some of the most scenic focal points of the Park, and their hydrology is linked to the nearby Gorongosa Mountain. With concerns about the stability of the wetlands in mind, the Carr Foundation has included Mt Gorongosa in its conservation interests. The state of the Mountain's catchment area was investigated, and extensive recent destruction of forest was observed. This was monitored in retrospect, with the aid of satellite imagery. The result showed that the slow removal of timber, up the mountain slopes, which commenced long ago, has accelerated exponentially since the turn of the century and by 2007 has reached alarming proportions. It was realized, that the protection of the remaining natural vegetation was of utmost importance, not for the protection of the catchments alone, but also to safeguard the unique biodiversity and scenic beauty of the Mountain itself. Since then, steps have been taken to annex the upper parts (above the 700m contour) of the Mountain to Gorongosa National Park and declare it a conservation area. In order to manage a conservation area, and to assess the conservation value of its flora, and also to facilitate possible ecotourism, knowledge of the vegetation is a necessary prerequisite. Hence the Carr Foundation commissioned this Vegetation Survey.

2. Objectives

- To carry out a vegetation survey of Gorongosa Mountain above the 700 metres contour, to classify the vegetation into types and to produce a vegetation map showing the distribution of the types.

- To provide a description of the vegetation types, indicating the vegetation structure, characteristic and major species, associated species, and plant species of conservation interest and concern.

- To provide ecological notes regarding important features and determining factors. To compile a species list recorded in the Study Area.

- To make suggestions on the reintroduction of native species. To make suggestions regarding a land use plan for the degraded lower slopes, which would render them more stable and would introduce sustainable agriculture where appropriate, and also take the natural biodiversity into account.

- To provide in-service training for a Mozambican botanist.

3. Literature Review

Two papers were identified which had some bearing on the flora of the Study Site. They were as follows:-

1. Framework of the Gorongosa Ecosystem after Tinley (1977) This is a large and comprehensive DSc Thesis, which includes some species lists of the Woody Vegetation of Mount Gorongosa, but apart from this, does not refer to it. However Tinley collected numerous plant specimens on the mountain, duplicates of which are housed in the National Herbarium of Zimbabwe and proved most useful when identifying the plant specimens from the Study Site.
2. Carta de Vegetaeao da Serra Gorongosa after de Aguir Macedo (1970) This publication gave a general account of the vegetation of Mt Gorongosa and proved most useful for gaining an initial overview, but it contained insufficient detail to help with the actual survey.

4. The Study Site

Mount Gorongosa is located in the Gorongosa District of the Sofala Province about 20km north-northeast of Gorongosa town and approximately 80km from the Indian Ocean, and falls mainly between the longitudes 33.50' East and latitudes 18.13' and 18.42' South.

The Study Site is the portion of the mountain which lies above the 700 metres contour, and is approximately 350 square kilometres in extent, whereas the entire Mountain covers an area of almost 700 square kilometres in size.

4.1 The Physical Environment

Mount Gorongosa is a gigantic Inselberg really more of a Massif than an individual mountain. It rises out of the Mozambique plane from altitudes of 350m to 450m above sea level, to over 1850m, and has a vertical relief of between 900 and 1400m. There are three main peaks, one toward the north, one in the south and one in the southwest, of which Mt Gogogo in the southwest, with an altitude of 1868m is the highest. Its outline is very roughly circular with a diameter of about 28km. The geology consists mainly of granites and some gabbros on the western and southern slopes. The morphology of the gabbros is undulating with gentle slopes up to 15º. Granites form steeper slopes up to 30º. and more, interspersed with cliffs, and generally bare rock is exposed over large areas.

The Mountain consists of a much larger northern portion, referred to in this report as the Main Massif, which is separated by the Vanduzi River valley from a smaller and lower southern portion, referred to as the Monte Nhassacassa Section. The Main Massif has a large inner portion sometimes referred to as the plateau, but it consists of three valleys, and its topography is, in many areas, rugged and steeply undulating, with scattered knolls and kopjes.

The general topography of the Main Massif is tilted from the west and north towards the southwest, with all the flatter high ground in the west. The Monte Nhassacassa section consists of a broad and undulating ridge, which gradually rises towards Monte Nhassacassa, a prominent peak that makes the southern end of the Mount Gorongosa Range.

The valleys of the inner section and the streams of the southern and some of the western slopes, drain into the Nhandare River which flows into the Pungwe. The eastern slopes of the Main Massif and some parts of the Nhassacassa Section drain into the Vanduzi River which joins the Nhandue River. The Nhandue River flows into Lake Urema of the Gorongosa National Park.

4.2 Settlements and Shifting-Agriculture

On the lower slopes of the Mountain, below the 700m contour, settlements have probably existed since the early parts of last century, or even longer, and most of the original woodland and forest has been removed long ago.

On the lower slopes of the Study Site, between the 700m contour and the zone of natural vegetation, practically all the original timber has also been cleared, but most of the clearing has probably occurred since 1950. However as mentioned earlier in this report, the clearing has accelerated in recent years. Settlements have come in over the last few decades, first lower down and more recently higher up.

A recent development, which commenced a few years ago, and which is still taking place, is the clearing of sizeable plots, several hectares in extent, for the purpose of growing potatoes as a cash crop, or maybe marijuana. This is taking place within the zone of natural vegetation, inside the Moist Evergreen Rainforest, up to an altitude of about 1500m or probably even higher.

Fig 3. recent clearing in montane forest.
Photo: Jeff Barbee

5. Methods of Investigation

An initial understanding of the vegetation patterns was gained by visually studying the R-G-B false colour composite of the relevant Land sat TM scenes and also by looking at some unsupervised classifications of the same images. This was carried out in conjunction with a helicopter flight over the entire Study Site, on which several stops were made for ground truthing. From this initial exercise the main vegetation types were recognized and an appreciation was gained of their spatial arrangements.

It became immediately obvious, that the whole mountain falls within two main categories of vegetation cover:

1. A lower zone, in which the natural vegetation has been greatly altered by the activities of people, and in which much of the original timber (woodland and forest cover) has been removed.
2. An upper zone, in which much of the natural vegetation was still well preserved.

Looking at the Study site on a map, the areas covered by each zone are roughly equal. However if one looks at the actual land occupied by each, the upper zone, because of the extremely dissected nature of its topography, is considerably larger.

The time frame for the Study required some priority setting with regards to survey activity. Considering the objectives of the investigation, it was obvious that the main focus had to be on the natural vegetation of the upper zone, and that much less attention could be given to the strongly altered vegetation of the lower zone.

Availability of a helicopter during the latter stages of the field work greatly facilitated sampling, and allowed access to some sites which otherwise could not have been reached in the time available for the study.

5.1 Location of sampling points

Sampling was initially planned by using the relevant Landsat scenes as well as panchromatic aerial photographs. Both were stratified into what appeared on them as homogenous units. These units were assumed to represent vegetation types. The stratification served as the initial framework for sampling. Following stratification, provisional sampling areas were located on the air photos. Major considerations when locating sampling sites, where to ensure reasonable sample coverage, a good geographical spread and a range of topographical positions. The actual sampling points were subjectively located during transects across the predetermined sampling areas. Great care was taken, that the sample represented a significant vegetation type and that it did not fall within an environmental boundary area. When sampling in the upper zone, due to the scarcity of foot paths and the often rugged terrain, access to sampling sites could be difficult and at times the sampling strategy was influenced by the problem of access.

The access routes to the various sample sites were used as transects on which the general composition of the vegetation was continuously examined so as to verify the

information gained during sampling, and also to build up an understanding of the vegetation patterns, and their relationships to the environment.

Fig 4. Survey team deciding where to begin.

Moist Evergreen Rainforest was a widely spread vegetation type in the natural upper zone, occurring at altitudes from approximately 1000 to 1800 metres. It is well known that species composition in Moist Forest changes with altitude; however the different forest types can not be discovered on satellite or air photos. Forests were therefore investigated, more or less randomly, at various altitudes in different parts of the massif. Apart from this a special investigation was made along, which is probably the longest forest catena found on the mountains, occurring beneath the main group of peaks on the southern slopes. Sampling took place from the top down and bottom up. Whenever a significant change in species composition was observed sampling of a new site was initiated.

5.2 Data Recording

Sampling was essentially plot less, but generally covered 1 to 2 hectares in forest or woodland and approximately 0.25 to 0.5 ha in grassland. A starting point was selected for each sampling plot. The investigation moved onwards from this point, covering all the ground and transversing an approximately circular area from the central point. A list of all species that could be identified was compiled, and the area of investigation was expanded until no new species were appearing. For each species, the cover abundance was visually assessed using a modified Braun-Blanquet scale (Table 1). In the Moist Evergreen Forest the woody species were recorded within each of the 5 strata, which are recognized in close canopy forest. In woodland or wooded grassland, the woody species were recorded in three height classes, less than 0.5m (mostly regenerating), 0.5-3m (shrubs and young trees) and more than 3m trees and large shrubs. Care was taken to ensure, that in the process, the investigation did not stray across the boundaries of a different vegetation unit.

Table 1. The Modified Braun-Blanquet Scale

Species frequency & estimated area cover	Braun-Blanquet Symbol
Few, with small cover	**+**
Numerous, but less than 5% cover, or scattered with up to 5% cover	**1**
Any number with 5-25% cover	**2**
Any number with 25-50% cover	**3**
Any number with 50-75% cover	**4**
Any number with more than 75% cover	**5**

Altogether 127 sites were investigated, 111 of them in the natural upper zone and 16 in the lower zone. In the upper zone, 48 of the sites were in Moist Evergreen Forest, 31 in grassland, 23 in wooded grassland, and 8 in microphyllous (ericoid) scrub and 1 in Miombo Woodland (*Brachystegia*-Woodland). In the lower zone 3 of the recording sites were in riparian forest and the remainder in woodland remnants and grassland.

To gain an understanding of the distribution of the dominant grassland types, and also to assist with the mapping of grasslands, frequent recordings of the dominant and indicators species, together with G.P.S. readings, were made at various points on the access marches (mini-samples).

A checklist of all species recorded, giving their growth form and the main vegetation type in

which they occur, is given in appendix 1. The species lists of the plants recorded in each site are given in Appendix 2.

Field work took place from the 16th of April to the 4th of May 2007 and from the 13th of June to the 24th of June 2007. Most of the field work was carried out on foot from base camps; altogether 7 base camps were used. The time spent walking to the site was considerable. During the second period of field work a helicopter was available on 6 days.

The species based classification of the occurring vegetation type was derived at subjectively during field work and subsequently from the field sheets. Since only a few main vegetation types were involved a computer- aided analysis was deemed unnecessary.

6. Evaluation and Description of the Vegetation

6.1 General Consideration

Mount Gorongosa falls within the pan tropical belt of summer seasonal rainfall which has a pronounced dry season of 6 to 8 month, and floristically most of the surrounding country belongs to the Zambesian Regional Centre of Endemism (White 1988), which consists of vegetation adapted to withstand prolonged periods without water. However, because of the height of the mountain, its upper parts, especially the ocean facing slopes, receive sufficient orographic rain and mist during the winter month, to allow, over many parts of the mountain, for the existence of a much less xeromorphic vegetation, than is found in most other parts of Mozambique.

Fig 5. Near-endemic *Jamesbrittenia carvalhoi* in montane grassland.

A further range in vegetation variation is caused by the different temperature regimes that prevail at different altitudes. In addition, the relief of a mountain, as well as the often abrupt changes in soil depth, can cause sharp differences in available moisture over very short distances. This in turn causes sharp environmental boundaries, and as a consequence, one finds in many areas, the juxtaposition of quite different vegetation types. Soil moisture conditions and altitude

(temperature) are assumed to be the main environmental factors that determines the vegetation types and their boundaries.

Much of the inner portion of the main massif, the upper parts of the Monte Nhassacassa section, the upper portions of the plane facing slopes and to a lesser extent the upper slopes of the Vanduzi Valley was covered with Moist Evergreen Forest. As one moved down the slopes, out of the mist belt towards areas of lower and less frequent rainfall, the areas covered by Moist Evergreen Forest became increasingly relief related and therefore more fragmented. This pattern would have been more obvious before the extensive clearing of woodland and forest which took place, over a long period, on the lower slopes. It is assumed, that before this clearing, practically all parts of the slopes, which were too dry for the development of Moist Evergreen Forest, were covered with woodland, essentially types of Miombo (*Brachystegia*) Woodland. By 2007 extensive areas of the original woodland were extremely rare, and generally it was only found in widely scattered small remnants.

6.2 The Vegetation of the Natural Upper Zone

Apart from the Moist Evergreen Forest which has still remained on the outer slopes, the major areas of floristic interest were the inner portion of the main massif and the upper parts of the Monte Nhassacassa section, where the vegetation was, over most parts, still in its natural state. Here, in areas which were either too dry (rocky slopes), or to wet (seasonally water logged), to maintain Moist Evergreen Forest, other vegetation types occur. These were mainly dominated by grasses and sedges or microphyllous scrub. Moist Evergreen Forest had sharp and clearly defined boundaries, where as the other vegetation types could sometimes grade into each other.

The following main vegetation types were recognized:-

1. Moist Evergreen Forest
2. Montane Grassland
3. Sub-montane Grassland
4. Wetland
5. Wooded Grassland
6. Ericoid Scrub
7. *Erica hexandra – Rhytidosperma macowanii* Open Scrub
8. *Widdringtonia nodiflora* Forest
9. *Brachystegia tamarindoides* Woodland
10. *Brachystegia spiciformis* Woodland

6.3 Moist Evergreen Forest

Fig 7. High-altitude forest dominated by *Trichocladus ellipticus*.

Viewed along a moisture gradient, the Moist Evergreen Forests of Southern Africa represent the dry end of tropical rainforest development. They have much lower species richness than the forests of the equatorial belt, and their constituent plants show a relatively high degree of xeromorphic adaptation. Physionomically and structurally however, they resemble tropical rainforest. Some of the trees are briefly deciduous, but the forest is generally evergreen.

Approximately 80 square kilometers of the natural upper zone was covered by Moist Evergreen Forest. Altitude was the principle factor correlated with species composition, and in accordance with the forest classification used for Zimbabwe Muller (1999), three forest types could be recognized. They were:

1. *Syzygium guineense* subsp *afromontanum* Montane Forest (above 1600 metres)
2. Mixed sub-Montane Forest (1300 to 1600m)
3. Medium Altitude Forest (900 to 1300m)

The altitudinal limits were approximate and varied considerably with aspect and relief. Superimposed on these three, fairly distinct altitudinal belts of vegetation types, there was an insipient and continuous change in species composition along the slope, with many of the species having their own specific altitudinal zone, and others occurring from top to bottom, but sometimes more commonly so, at a certain level.

On the outer mountain slopes, Moist Evergreen Forest has been continuously removed for many decades, mainly from the bottom upwards. In 1970 the main cutting-line, on the southern slopes, was observed to be between 900 and 1000 metres (personal observation). 2007 it was in the vicinity and above the 1100m contour in the south and south-east, but much higher on the northern slopes.

Since the different forest types can not be distinguished on air photos nor satellite images, estimates of the areas covered by the three respective types are difficult to make.

Montane Forest only occurred on the uppermost slopes towards the main peaks, and in some isolated patches on high ground in the central area. It is estimated that it comprised up to 15% of the total forested area.

Most of the forest which still occurred on the outer mountain slopes, and most of what covered the valleys and hills in the central area of the massif was Mixed Sub-montane Forest, and approximately 85% of the forest on the mountains can be assigned to this type.

Medium Altitude Forest occurred mainly in a few irregular narrow belts above 1100m, on the southern, south-eastern and eastern slopes, and also in some isolated patches (remnants) down to 900m, on the south-eastern most slopes. It was estimated that Medium Altitude Forest covered less than 5% of the total forest area, all of it under severe threat. Cutting of timber was observed in several localities during field work in June 2007.

6.3.1 *Syzygium guineense* subsp *afromontanum* Montane Forest

All forest above an altitude of 1600m belonged to this type. Often the dominant canopy tree species was *Syzygium guineense* subsp. *afromontanum*, with *Aphloia theiformis*, *Macaranga mellifera*, *Maesa lanceolata*, *Olea capensis* subsp. *macrocarpa*, *Podocarpus latifolius*, *Rapanea melanoploeos*, important and sometimes dominant components and *Chionanthus foveolatus* subsp. *major*, *Cryptocaria liebertiana*, *Curtisia dentata*, *Ilex mitis*, *Pittosporum viridiflorum*, *Schefflera umbellifera*, *Trichocladus ellipticus* (fig 7) and *Widdringtonia nodiflora* typically present. Passed disturbance was indicated by the dominance of *Macaranga mellifera*.

The often merging and poorly developed sub-canopy and sapling layer mainly consisted of young specimens of the canopy trees. *Tabernaemontana stapfiana* and *Xymalos monospora* were characteristic sub-canopy species and *Canthium oligocarpum* subsp. *captum*, *Cassinopsis tinifolia*, *Dovyalis lucida* and *Oxyanthus speciosus* prominent in the sapling layer.

Common species in the well developed shrub layer were *Acanthopale pubescens*, *Carissa bispinosa* subsp. *zambesiensis*, *Erythrococca polyandra*, *Gymnpsporia mossambicensis*, *Maytenus acuminata*, *Pavetta comostyla*, *Peddiea africana*, *Psychotria zombamontana* and *Pauridiantha symplocoides*.

Fig 8. Dietes iridioides on the forest floor.

The most conspicuous lianas were *Cephalanthus natalensis*, *Keetia gueinzii*, *Secamone alpini*, *Schefflera goetzenii* and *Urera hypselodendron*.

The ground cover was generally sparse and patchy, common herbs were *Cryptostephanus vansonii*, *Dietes iridioides* (fig 8), *Impatiens cecilli*, and *Plectranthus swynnertonii*. Occasional grass species were *Coelachne africana*, *Festuca africana* and *Isachne mauritiana*.

Fi6.3.2 Mixed Sub-montane Forest

This forest type was essentially a mixture of species from the Montane Forest above and the Medium Altitude Forest below. In its upper parts, the montane species were more prominent and lower down the ones from below, and its altitudinal range is between 1300 and 1600m.

The most typical and often dominant canopy species was *Craibia brevicaudata* subsp. *baptisarum*. Other important sometimes dominant components of the canopy were *Cassipourea malosana, Chrysophyllum gorungosanum, Macaranga mellifera* (when dominant a sign of passed disturbance) *Olea capensis* subsp. *macrocarpa*, *Podocarpus latifolius, Strombosia scheffleri* (normally below 1450m) and *Syzygium guineense* subsp. *afromontanum*. Less frequent but typical large trees were *Albizia gummifera, Croton sylvaticus, Cryptocarya liebertiana, Diospyros abyssinica, Ekebergia capensis, Ficus chirindensis, Ficus craterostoma, Ficus scassellatii, Margaritaria discoidea* var. *nitida, Nuxia congesta* and *Pterocelastrus echinatus*. *Ocotea kenyensis* was a rarely encountered large canopy species. The most common big sub-canopy species was *Tabernaemontana stapfiana* with the often smaller *Ochna arborea* also common. Other typical members of the sub-canopy and sapling layer were *Canthium oligocarpum* subsp. *captum*, *Chionanthus flaveolata* subsp. *major*, *Cola greenwayi*, *Drypetes gerrardii, Englerophyton mahaglismontanum, Erythroxylum emarginatum, Garcinia kingaensis* (especially on steep slopes). *Heinsenia dievilleoides, Ochna holstii, Oxyanthus speciosus, Rawsonia lucida, Rothmannia urciliformis, Vangueria esculenta, Vepris bachmannii* and *Xymalos monospora*.

Fig 9. Acanthopale pubescens

The shrub layer was normally distinct and well developed. Shrubs common in the Montane Forest such as *Carissa bispinosa* subsp. *zambesiensis*, *Erythrococca polyandra, Gymnosporia mossambicensis, Pavetta comostyla, Peddiea africana* and especially *Psychotria zombomontana* and *Pauridiantha symplocoides* were still frequently encountered. Additional typical and sometimes common shrubs were *Achyrospermum carvalhi, Coffea ligustroides, Diospyros ferrea* (normally a small tree, but here only recorded in the shrub layer) *Justicia betonica, Lasianthus kilimanscharicus, Mostuea brunonis, Piper capense* and *Rytigynia macrura*. *Dracaena fragrans* was increasingly common from 1450m downwards. The soft branched members of the **Acanthaceae**, *Acanthopole pubescens* (fig 9) and *Brachystephanus africanus* and to a lesser extent *Isoglossa mossambicensis* were sometimes locally very common often forming extensive dense patches.

Keetia gueinzii, Schefflera goetzennii and *Urera hypseladendron* were the most frequent lianas, and *Hippocretea africana* var. *richardiana, Jasminum abyssinicum, Landolphia buchananii, Secamone alpini* and *Tiliacora funifera* were occasionally recorded climbing plants.

Typical herbaceous species in the rather patchy and sparse ground cover were *Dietes iridioides* (fig 8), *Impatiens cecillii, Plectranthus swynnertonii* and *Thunbergia petersiana*. *Calanthe sylvatica*, an attractive purple-pink orchid, was common in some places. The most frequently seen grass species were *Coelachne africana, Isachne mauritiana* and *Poecilostachys oplismenoides* .

6.3.3 Medium Altitude Forest

Fig 10. Giant *Newtonia buchananii*.

This forest type occurred at altitudes between 900m and 1300m and was characterized by the presence of *Newtonia buchananii* (fig 10), often dominant especially lower down, but always an important component. Other typical canopy species were *Albiza gummifera, Chrysophyllum gorungosanum, Craibia brevicaudata* subsp. baptisarum*, Croton sylvaticus, Diospyros abyssinica, Drypetes gerrardii , Echebergia capensis, Ficus chirindensis, Ficus craterostoma, Ficus scassellatii, Margaritaria discoidea* var. *nidida, Strombosia scheffleri,* and *Trichilia dregeana*. *Ocotea keniensis* was again recorded as a rare species and *Khaya nyassica* was noted in one locality below 1000m. *Albizia gummifera, Anthocleista grandiflora, Macaranga mellifera, Polyscias fulva, Rauvolfia caffra* and *Sapium elliplicum* were characteristic species of disturbed sites.

Common species in the sub-canopy and sapling layer were *Aidia micrantha, Cola greenwayi, Heinsenia diervilleoides, Garcinia kingaensis* (mainly on steep slopes), *Ochna arborea, Oxyanthus speciosus, Rawsonia lucida, Rothmannia urcilliformis, Strychnos usambarensis, Vangueria esculenta* and *Vepris bachmannii*.

In the well defined shrub layer. *Dracaena fragrans* was very common in the upper parts, where it often covered extensive areas. Characteristic shrubs not found higher up were *Allophyllus chaunostachys, Argomuellera macrophylla, Clerodendrum cephalanthum* subsp. *swynnertonii*, *C. pleiosciadium*, *Cremaspora triflora, Dracaena mannii* (also in the sapling layer), *Mellera lobulata, Psychotria capensis* subsp. *capensis, Rinorea ferruginea, Rutidea orientalis, Rytigynia uhligii, Tarenna pavettioides* (also in the sapling layer) and *Tricalysia pallens*. Shrubs also found higher up but still prominent were *Achyrospermum carvalhii, Carissa bispinora* subsp. *zambesiensis, Coffea ligustroides, Diospyros ferrea, Justicia betonica, Mostuea brunonis, Peddiea africana, Psychotria zombamontana* and *Rytigynia macrura*.

There were many species of lianas, the most common ones were *Acacia pentagona, Agelaea pentagyna, Combretum paniculatum, Embelia schimperi, Gouania longispicata, Hippocratea africana* var. *richardiana, Landolphia buchananii, Landolphia kirkii, Oncinotis tenuiloba, Strychnos lucens* and *Tiliacora funifera*.

The ground cover was often dense, with the sub-shrub *Pseuderanthemum subviscosum* and the up to 2 metres tall *Afromonum angustiflolium* very common. Seedlings of the common lianas

especially *Agelaea pentagyna* contributed substantially to the lower strata. Common grass species were *Isachne mauritiana, Leptaspis cochleata, Oplismenus compositus, Oplismenus hirtellus, Poecilostachys oplismenioides* and *Setaria megaphylla*.

6.3.4 The State of the Forests

Mature undisturbed Moist Evergreen Forest can be recognized by its age structure and its stratification. It has an age structure in which all age classes are represented, and all of them have their characteristic distribution patterns, which vary for different species, mature trees occur in more or less set numbers per unit area. Stratification of the woody vegetation is normally distinct, consisting of three layers at higher altitudes (canopy, sapling layer and shrub layer) and four layers lower down (+ sub-canopy).

In most of the 48 forest stands investigated, there was rarely a continuous canopy, and stratification of the middle layers was normally poor. Forest which showed a mature age structure was rarely observed and occurred normally only over relatively small areas.

The best preserved forest seen, was in Stand 36, which was in a remote area of the middle section of the main Massif and consisted of Mixed sub-Montane Forest with a canopy height of 45 metres. Simultaneous to the investigation, clearing of several hectares of forest took place, in the inner section of this fairly extensive forest. Reasonably well preserved Sub-montane Forest occurred in the vicinity of stand 35A and 177, and good Montane Forest was observed in stand 165. Well preserved Medium Altitude Forest was only seen covering relatively small areas.

Canopy height of the forest was 15 to 20 metres in the upper most areas, gradually increasing downwards to over 50 metres in the Medium Altitude Forest.

The most species rich part of the forest is the Medium Altitude Forest between 900 and 1100m (its lower portion). Tree clearing at this altitude was observed during field work in April and June 2007, on the southern and eastern slopes of the main Massif and the south eastern slopes of Monte Nandondo on the Monte Nhassacassa section.

The scarcity of undisturbed mature forest leads to the assumption, that prehistoric shifting agriculture could have taken place in the forests of the Mountain. This would have caused unnaturally large openings, making the forest more prone to damage by storm and possibly fire . For a forest to reach maturity from ground level could take several hundred years.

Fig 11. Montane grassland below Nhandowe Peak with *Helichrysum* species, small shrubs of *Kotschya thymodora* and the tree fern *Cyathea dregei* in the seepage of a small stream.

6.3.5 Forest Edge Vegetation

Fig 12. *Aloe arborescens* at the forest edge.

Along the margins of the forests, there was almost everywhere a distinct belt of forest edge vegetation, which had a different species composition to the one found inside the forest, with only a few species occurring on the margin and inside. Most of the edge species were shrubs, and the tree species among them, has normally a shrubby habit. The species composition of the forest margin changed little with altitude and generally similar species were found from 1300m to 1800m. Typical forest edge species were *Aphloia theiformis, Buddleja salviifolia, Cassinopsis ilicifolia, Cassinopsis tinifolia, Cliffortia serpyllifolia, Clutia swynnertonii, Crotelaria capensis, Cussonia spicata, Erica hexandra, Halleria lucida, Heteromorpha arborescens* var. *abyssinica, Hypericum revolutum, Macaranga mellifera, Maesa lanceolata, Morella pilulifera, Myrsine africana, Pavonia columella, Polygala gazensis, Polygala virgata, Protea caffra* subsp. *gazensis, Rapanea melanophloeos, Rhus chirindensis, Rhus tumulicola, Rubus apetalus, Schefflera umbellifera Smilax anceps, Sparrmannia ricinocarpa, Tephrosia aequilata* subsp. *mlanjeana and Widdringtonia nodiflora*. Prominent herbaceous species were *Helichrysum nudiflora*, the often over 1m tall *Impatiens psychadelphoides*, the fern *Pteridium aquilinum* and the tussock grass *Rytidospesma macowannii*.

6.4 Montane Grassland

Fig 13. Unusual variety of Gladiolus crassifolius in montane grassland

Montane grassland occurred only in the highest part of the mountain on the main Massif, at altitudes from 1700m to 1820m, often on flattish or gently sloping ground, but sometimes on steeper slopes of up to 30º. The bulk of the sward was made up of two fine leaved species of **Cyperaceae** referred to in this study as "blue sedge" and "green sedge". No flowering material could be found during April and June and the two important species could not be identified. Often the most common grass species was *Festuca abyssinica*, other typical grasses were *Eragrostis volkensii, Eulalia villosa, Panicum ecklonii* and *Setaria sphaceolata*. Less frequent grass species were *Andropogon schirensis, Digitaria maitlandii, Ischaemum fasciculatum*, and

Trichopteryx dregeana. *Loudetia simplex* was mainly present in patches with out cropping rock. Herbs made up an important portion of the ground cover and the most common herbaceous species were *Helichrysum buchananii, Helichrysum nitens* and *Vernonia natalensis*. Other common herbs were *Eriosema psoraleoidies, Haumaniastrum venosum, Indigofere hedyantha, Kotschya thymodora* (fig 11), *Lotus wildii, Rhynchosia clivorum* and *Sopubia mannii*. Typically present herbaceous species were *Alepidea swynnertonii, Aloe rhodesiaca,*
Gladiolus crassifolius (fig 13), *Kniphofia linearifolia, Knowltonia transvaalensis, Sabaea leiostyla* and *Jamesbrittenia carvalhoi* (Fig 5). The fern, *Pteridium aquilinum* occurred over much of the grassland, never very common, but always present.

6.5 Sub-montane Grassland

Fig 14. Sub-montane grassland in the upper Nhandar Valley with spectacular *Kniphofia splendida* in flower.

Sub-montane grassland occurred from 1300m to 1700m over extensive areas, on the more gentle hills and valleys in the central portion of the main Massif, and also on some of the higher ground of the Monte Nhassacassa Section. Its species composition was generally similar to the Montane Grassland. The main differences were that *Loudetia simplex* was the most common and often dominant grass species, *Monocymbium ceresiiformis* an important associate and *Hyparrhenia newtonii* a typically occurring grass. The "green sedge" and "blue sedge" were always present, but not as prominent as higher up. The grass *Erapostis acraea* formed large patches in some areas but was absent in others. Apart from this the grass and herbaceous species were similar to the ones occurring higher up.

6.6 Wetland

Wetlands are areas with higher soil moisture content than the surrounding land, they occurred at the lower end of grassland slopes, along drainage lines and in the vicinity of stream valleys. They normally covered smallish areas of about 1 to 5 hectares and occurred occasionally throughout the Study Site at altitudes from 130m to 1720m. The species distribution within the wetlands was often clumped and patchy, and in some places different vegetation sub-units could be discerned. The species composition was generally similar throughout the altitudinal range except for one **Cyperaceae** which was only recorded above 1680m, where it was dominant and gave the wetlands a brownish appearance. No fertile material could be found and identification was impossible. The plant was referred to as "brown sedge" in the Study.

The bulk of the plant mass in wetlands is normally made up of **Cyperaceae** (sedges), unfortunately a number of them could not be identified. *Costularia natalensis* was an often prominent and sometimes dominant sedge, *Xyris gerrardii* typically present but of little bulk, and the "blue sedge" and "green sedge" were generally important components. Common grass species were *Eragrostis volkensii, Eulalia villosa* and *Setaria sphacelata*, and *Eragrostis* was occasionally present in patches. Herbs were present but rarely conspicuous. Typical herbaceous species were *Eriosema psoraleoides, Gerbera ambigua, Haumaniastrum venosum, Helichrysum odoratissimum, Kniphofia linearifolia* and *K. splendida* (fig 14), *Sebaea leiostyla* and *Schistostephium artemisiifolium*. The fern *Pteridium aquilinum* was often present and sometimes quite common.

6.7 Wooded grassland on rock

Wooded grassland occurred on knolls and kopjes but also on broad mountain slopes with outcropping rock. Normally the woody species were clumped or irregularly scattered and their number increased with an increase of outcropping rock. Where there was little rock there were widely scattered *Protea caffra* subsp. *gazensis*, and a few *Morella pilulifera* and *Strelitzia caudata* (fig 16). With more rock the species composition increased to a complex assemblage.

Fig 15. Clumps of the sedge *Coleochloa setifera* survive on bare rock surfaces, where they are often bizarrely sculpted by fire and weather conditions.

There were generally the same species which were typical of forest margins. The most typical and common tree species were *Cussonia spicata*, *Erica hexandra* (often a shrub) *Morella pilulifera, Strelitzia caudata* and *Widdringtonia nodiflora. Aphloia theiformis, Ilex mitis, Curtisia dentata, Apodytes dimidiata*, *Macaranga mellifera, Maesa lanceolata* and *Schefflera umbellifera* were all trees normally found in Moist Evergreen Forest, but commonly occurred as stunted specimens on rocky slopes. The most common and typical shrub species were *Aeschynomene nodulosa* var. *glabrescens* (fig 16), *Aloe arborescens* (fig 12), *Buddleja salviifolia, Clutia swynnertonii, Cliffortia serpyllifolia, Halleria lucida, Heteromorpha arborescens* var *abyssinica, Myrsine africana, Protea caffra* subsp. gazensis, *Rhus chirindensis, Rhus tumulicola, Rubus apetalus, Tephrosia aequilata* subsp. *mlanjeana, Tetradenia riparia* and *Vangueria apiculata*. Characteristic smaller plants were *Aloe rhodesiaca,*

Berkheya zeyheri, Diplolophium buchananii, Kotschya thymodora, Plectranthus chimanimaniensis, and *Thesium nigricans*. *Loudetia simplex* was generally the most common grass. but higher up (above 1650) *Festuca abyssinica* and *Rytidosperma macowanii* could be very common and below 1700m *Eragrostis acraea* was locally occurring in large patches. A striking and very common feature on bare rock was the tussock sedge, *Coleochloa setifera* (fig 15), which was occuring in rock cracks, and besides the occasional specimens of *Crassula nodulosa* var. *nodulosa* and *Crassula swazienis* var. *swaziensis* was the only plant that could survive in this habitat.

6.8 Ericoid Scrub

Ericoid scrub occurred on similar rocky slopes as the above described Wooded Grassland and contained almost the same species assemblage. However the vegetation was almost impenetrably dense and dominated by *Erica hexandra* with *Widdringtonia nodiflora* also common. From a view point it could be observed that Ericoid Scrub sometimes merged into almost pure stand of *Widdringtonia* Forest. The extent of Ericoid Scrub was difficult to estimate, but it seemed fairly common on some of the valley slopes in the central parts of the Massif.

Fig 16. Flora on exposed rock often includes similar components as ericoid scrub, such as *Erica hexandra, Aeschynomene nodulosa* and the banana-like *Strelitzia caudata.*

In areas where the slope flattened, the scrub was often less dense and *Erica hexandra* less dominant. Here *Aeschynomene nodulosa* var*. glabescens* or *Anthospermum ammannioides* were common or dominant and Morella *pilulifera, Rhus tumulicola, Stoebe vulgaris, Tephrosia aequilata* subsp. *mlanjeana* and *Tetradenia riparia* prominent shrubby species, and the fern *Pteridium aquilinum* typically present. (Stands 175 and 186). Similar associations were observed in the flatter portion of slopes covered with Wooded Grassland

6.9 *Erica hexandra – Rhyidosperma macowanii* Open Scrub

This was a seldom observed association occurring on slopes close to Moist Evergreen Forest. There was an open shrub layer consisting of *Erica hexandra* and *Cliffortia serpyllifolia* interspersed with *Morella pilulifera*. In between there was a ground cover in which the tussock grasses *Rytidosperma macowanii* and the tussock sedge *Costularia natalensis* were common and *Setaria sphaceolata* frequent. Typical herbaceous species were *Eriosema psoraleoides*, Kniphofia *linearifolia* and *Nidorella auriculata*. A similar association was observed immediately to the north of the forest Stand 35A. However here the vegetation consisted mainly of *Rytidosperma macowanii* interspersed with the fern *Pteridium aquilinum*.

6.10 *Widdringtonia* Forest

Widdringtonia Forest occurred in narrow belts within the Ericoid Scrub or Wooded Grassland. It is estimated that only a few hectares of it exist on the Mountain. The canopy is made up of *Widdringtonia nodiflora* only or sometimes *Erica hexandra* can be a frequent associated species. The sub-canopy and sapling layer consisted of Moist Evergreen Forest species such as *Aphloia theiformis, Garcinia kingaensis, Macaranga mellifera, Olea capensis, Podocarpus latifolius*, *Rapanea melanophoeos, Schefflera umbellifera*, and *Xymalos monospora*. The lower part of the forest was very open. Typical species recorded in the widely scattered shrub layer were *Cassinopsis tinifolia, Cliffortia sepyllifolia, Clutia swynnertonii, Morella pilulifera, Psychotria zombamontana, Rubus apetalus* var. *apetalus*, *Rhus tumulicola* var. t*u*mulicola and *Smilax anceps*. In the sparse ground cover *Pteridium aquilinum* was prominent. The forest consisted of even aged fairly young trees, suggesting that it occasionally burns down.

6.11 *Brachystegia tamarindoides* Woodland

Brachystegia tamarindoides – Woodland was only observed on the north-western slopes of the Monte Nhassacassa section where it covered approximately 25 hectaers in a more or less continuous stand. The canopy was made up almost entirely of *Brachystegia tamarindoides*. Other typical tree species, all of them smaller, were *Albizia adianthifolia. Albizia versicolor, Anthocleista grandiflora, Bridelia micrantha, Burkea africana, Dalbergia nitidula, Englerophyton magalismontanum, Entada abyssinica, Erythrophleum suaveolens, Harungana madacascariensis, Morella pilulifera, Parinari curatellifolia, Ptericopsis angolensis, Pterocarpus angolensis, Securidaca longipedunculata* and *Syzygium cordatum*.

Typical shrub species were *Aeschynomene nodulosa* var. *glabescens, Erythroxylum emarginatum, Psorospermum febrifugum, Rhus chirindensis, Smilax anceps, Tarenna pavettoides, Tephrosia aequilata* subsp. *mlanjeana, Tricalysia pallens, Vangueria apiculata* and *Vangueria infausta*.

Fig 17. One of a number of new records for Mt Gorongosa was the rare fern *Asplenium holstii*.

Loudetia simplex and *Melinis nerviglumis* were the most common grass species and *Afromomum angustifolium*, normally found in Moist Forest was occasionally seen in the ground cover. The trees were covered with epiphytes, mainly orchids and ferns and the conspicuous lichen *Osnea*.

An interesting record was the very rare *Asplenium holstii* (fig 17), it has a simple frond and strongly resembles the cultivated birds nest fern (*Asplenium nidus*) from Australasia.

The canopy was in many places almost continuous with a cover of 80 to 90%, and there were many mature trees of up to 25 metres in height. Generally the woodland was reasonably well preserved. However there were obvious signs indicating that tree cutting has recently taken place.

Fig 18 & 19. One of threats to the areas of Miombo woodland is the construction of beehives from tree bark.

6.12 Brachystegia spiciformis Woodland

This was only seen through binoculars, on the upper western slopes, and there was no time available to investigate it.

6.13 The Vegetation and Fire

It is assumed that the natural limits of the Moist Evergreen Forest are generally determined by soil moisture and fire has little influence on the boundaries. This is bome out by the fact, that when comparing the present boundaries with the ones shown on air photos taken 37 years ago, no significant change in the outline of the forests can be observed.

However, considering the strong fires which regularly take place in the open areas of the mountain, one must assume that the vegetation patterns and the successional development of all plant communities, that occur between grassland and Moist Evergreen Forest, are greatly influenced by fire. There might, over large areas, be a natural progression from wooded grassland towards Ericoid Scrub and further towards *Widdringtonia nodifloria* Forest, which is regularly set back again by fire. In some areas the fire regime might be such, that the final stages are never reached. These successional processes are also affected by soil moisture conditions, which are very variable in mountainous terrains and fire superimposed on areas with variable soil moisture conditions, will increase the heterogeneity of the vegetation. Generally in high rainfall areas of seasonal rainfall, where strong fires prevail, like on Mount Gorongosa, plant communities with woody components, are much more influx, than they would be with less or not fire.

6.14 The Vegetation of the Modified Lower Zone

This zone is artificial, but constitutes a useful unit for the purpose of this study. It was created by the removal of most of the Woodland and Moist Evergreen Forest, which, at one time, must have covered almost all of the lower slopes of the Mountain. It extends from the boundary (the 700m contour) up to the edge of the zone of well preserved natural vegetation, and makes up more than half of the Study Site (approximately 200 square kilometers). Its upper boundary is ill defined and jagged and varies in altitude between approximately 1000m and 1200m. Over large areas the natural vegetation has been obliterated to make space for agricultural land and villages.

Much of the area where there was previously Miombo Woodland was still covered with the original grassland, although most probably strongly modified by the different fire regime. In some areas the grassland contained small remnants of the original trees and regenerating woody vegetation (mostly small). The areas previously covered with Moist Evergreen Forest, if not converted to agricultural land, were covered with secondary grassland, which often contained scattered young trees of forest edge and forest pioneering species, of an assemblage which is typically for degraded high rainfall situations. Very occasionally, there were remnants of often degraded Moist Evergreen Forest.

6.14.1 The Vegetation on the Western Slope (Stand 163 to 180)

The western slopes are rain shadow country and most of them were once covered with Miombo Woodland, with Moist Evergreen Forest found only higher up in concave areas and along drainage lines.

Fig 20. Particularly the North-western slopes of the mountain fall within its rain shadow. They are less densely populated due to lack of suitable agricultural land and some remnants of the former the woodlands are left.

The slopes were essentially occupied by field, fallow land and grassland which in some areas contained widely scattered woodland trees and isolated pockets of woodland remnants. Very few narrow ribbons of Moist Evergreen Forest were observed in the upper most section of the zone. Typical tree species recorded were *Acacia karroo, Brachystegia boehmii, Combretum zeyheri, Cussonia arborea, Diplorhynchus condylocarpon, Dombeya rotundifolia, Erythrina abyssinica, Faurea saligna, Pericopsis angolensis, Pteocarpus rotundifolia, Securidaca longipedunculata* and *Stychnos spinosa*. Characteristic shrubs were *Annona senegalensis, Diospyros lycioides, Senna petersiana* and *Vangueria infausta*. All species were typical components of Miombo Woodland, *Acacia karroo* is the most important woodland pioneer species in the lower parts of the Mountain. The most common grass species were *Cymbopogon caesius, Hyparrhenia cymbaria, Hyparrhenia filipendula, Hyparrhenia newtonii, Hyparrhenia rufa, Melinus repens* and *Themeda triandra*.

6.14.2 The Southern Slopes (Stands 148 to 156)

Where there were no fields and fallow lands, there was grassland, which often contained regenerating woody species. Much of the grassland appeared to be secondary, covering areas where Moist Evergreen Forest had been cleaned. However in many areas it was not obvious whether it was Moist Forest or Woodland that had been removed and more field work would be needed to establish the actual pattern. Typical tree species recorded were *Acacia karroo, Albizia adianthifolia, Bridelia micrantha, Cussonis spicata, Dalbergia boehmii, Dalbergia nitidula, Erythrina lysistemon, Ficus sur, Harungana madagascaniensis, Heteropyxis natalensis, Parinari curatellifolia*, *Pericopsis angolensis, Ptercarpus rotundifolius, Syzygium cordatum* and *Trema orientalis*. Often these trees occurred at a height of below 3 metres as low suckers, but sometimes as about 5 metres tall widely scattered small trees, and rarely they form patches of secondary woodland with a canopy of up to 10 metres in height.

Fig 21. On the Southwestern slopes, large areas of Miombo woodland were cleared many years ago to create glazing for cattle. Due to regular fires, these areas have now become well-established grasslands with only scattered pockets of the original woodland or forest in more sheltered places.

Typical shrub species were *Aeschynomene nodulosa* var. *glabrescens*, *Annona senegalensis, Dombeya burgessiae, Heteromorpha arborescens* var. *abyssinica, Polygala gazensis, Protea caffra subsp. gazensis, Psorospermum febrifugum*, *Rhus chirindensis, Smilax anceps, Tephrosia aequilata* subsp. *mlanjeana, Tephrosia vogellii*, *Vangueria infausta* and Vangueria *apiculata*.

The common grass species were *Cymbopogon caesius, Hyparrhenia cymbaria* (often dominant), *Hyparrhenia filipendula, Hyparrhenia rufa, Loudetia simplex* (sometimes dominant sometimes absent) *Melinis nerviglumis, Melinis repens, Panicum maximum* and *Paspalmum scrobiculatum*. The fern species *Pteridium aquilinum* was often present and the forest herb *Afromomum angustifolium* was noted frequently.

Tree species recorded along streams were *Anthocleista grandiflora, Apodytes dimidiata, Breonadia salicina, Catha edulis, Cussonia spicata, Ficus sur, Filicium decipiens, Khaya anthotheca, Macaranga mellifera, Maesa lanceolata, Mimusops zeyheri, Newtonia buchananii, Shirakiopsis (Sapium) ellipticum* and *Syzygium cordatum*.

6.14.3 The Eastern Slopes (Stands 199)

Only one investigation was carried out on the eastern slopes, close to the 700m contour where remnants of the original woodland were looked at. The tree species recorded were *Acacia sieberiana, Albizia adianthifolia, Albizia versicolor, Bridelia micromtha, Combretum psidioides* subsp. *psidioides, Cussonia arborea, Dalbergia boehmii, Markhamia obtusifolia, Millettia stuhlmannii, Pericopsis angolensis, Philenoptera violacea, Pterocarpus angolensis, Strychnos spinosa, Terminalia sericea* and *Vitex payos*.

Typical shrub species were *Annona senegalensis, Antidesma venosum, Psorospermum febrifugum, Senna petersiana, Smilax anceps, Tephrosia vogelli,* and *Vangueria infausta*. *Hyparrhenia cymbaria* and *Panicum maximum* were the dominant grasses.

This species assemblage might be typical of the lower slope, but not of the eastern slope as a whole.

6.14.4 Slopes of the Nhassacassa Section

Only one area was looked at which was on north-northwest facing slopes above the Vanduzi River.

The slopes in this area were covered with extensive grasslands which contained a variety of regenerating woody species most of them young and below 3m in height. Typical regenerating tree species were *Albizia adianthifolia, Bridelia micrantha, Burkea africana, Cussonia spicata, Dalbergia boehmii, Dalbergia nitidula, Ficus sur, Harungana madageascariensis, Morella pilulifera, Heteropyxis natalensis, Pericopsis angolensis* and *Syzygium cordatum*. Characteristic shrubs were *Aeschynomone nodulosa* var. *glabrescens* (widespread), *Annona senegalensis, Hymenocardia acida, Mussaenda arcuata, Psorospermum febrifugum, Rhubus apetalus, Smilax anceps, Tetradenia riparia and Tephrosia aequilata* subsp. *mlanjeana* (common).

The most common grass species were Hyparrhenia *filipendula, Loudetia simplex, Melinus minutiflora, Melinus nerviglumis* and *Paspalum scorbiculatum*. The fern *Pteridium aquilinum* was common and a typical plant of this grassland type.

7. Conclusions

7.1. General Consideration

The vegetation of the Study Site fell into two distinct zones.

1. A Lower Zone, in which almost all of the forest and woodland has been removed and which contains settlements. This zone was similar in physiognomy to the area between the 700m contour and the base of the mountain, except that there were fewer settlements and shifting agriculture was less intense. Apart from the riparian vegetation of the watercourses, the zone contained little that is of special conservation interest.
2. An Upper Zone in which much of the original natural vegetation is still well preserved and unspoiled and which is considered important for nature conservation. The boundary between the two zones was, in many parts ill defined and often jagged and frayed, and lay mainly between the 1100m and 1200m contour but sometimes higher.

7.2. The Stability of the Environment

The condition of the veld in the Lower Zone looked generally stable, despite the removal of timber, mainly because of the scarcity of livestock. The prevailing shifting agriculture is posing a potential threat to the stability of the mountain slopes.

The physical environment of the Upper Zone is in a stable condition. The clearing of land in the moist evergreen forest constitutes an enormous threat to its biodiversity. If the number of goats on the mountain is allowed to increase they too will have an adverse effect on the biodiversity and on the stability of the slopes.

7.3. Endangered Species and Endemism

To reliably analyze the long list of recorded species with regards to endemism and conservation status would take more time than is available for this consultancy, and would also involve assistance from specialists in the taxonomy of specific plant families. However it is assumed that a fair number of rare and endangered species have been recorded and that endemics occur.

Fig 22 & 23. *Cynorkis anisoloba and Polystachya subumbellata*; two new records for Mt Gorongosa.

Several species, thought to be endemic to the Eastern Highlands of Zimbabwe, were recorded also to occur on Mt Gorongosa. Two species of **Orchidaceae** in particular, *Polystachya subumbellatum* (fig 23) and *Cynorkis anisoloba* (fig 22), may actually have their largest populations on the mountain.

Many species were recorded for Mt Gorongosa for the first time, while others were new for Mozambique as a whole. The **Pteridophyta** in particular, appeared to be rich in species diversity, with many species recorded for the mountain for the first time (See Appendix 3 for a provisional list).

7.4. Conservation of the vegetation in the upper Zone

Vegetation of most of the upper zone consists of an interesting variety of Afromontane vegetation types, quite different from other vegetation in Mozambique. Its species richness and endemism is probably less than on similar mountains in Southern Africa. However its flora is still of sufficient interest to make it an important conservation priority There are other equally important considerations as follows:

- Afromontane vegetation types are of limited distribution and are extremely rare in Mozambique.
- For many species, the Mountain is the only locality where they occur in Mozambique . It contains many species which are generally rare and some endemics.
- The inherent qualities of the Mountain's vegetation, it pristine nature, its uniqueness and its juxtaposition of many of the ecosystems
- The fact that the vegetation is well preserved over much of the area
- The fact that the vegetation is an important component of an extremely beautiful landscape which has potential for eco tourism
- The fact that the vegetation protects an important catchment

7.5. Management

Initially, concern for the Mountain's conservation focused on environmental stability. If the Mountain were a National Park it would be easier to achieve continued environmental stability.

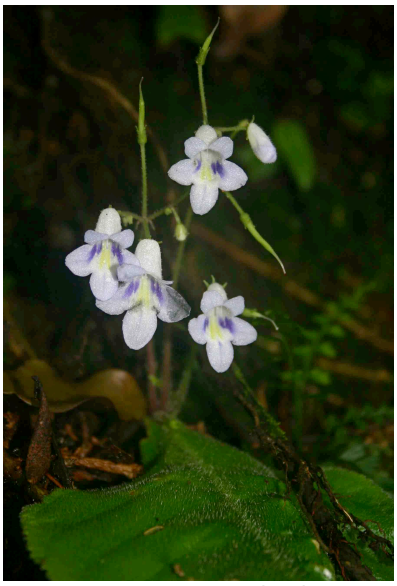

Fig. 24. *Streptocarpus brachynema*, a true endemic only found in the montane forests of Mt Gorongosa.

7.5.1 Management of the Upper Zone

In the natural Upper Zone, (the main catchment area), the only management required is the protection of the vegetation. If the vegetation cover is maintained, stability is maintained. Conservation is here the appropriate intervention to achieve environmental stability.

7.5.2. Management of the Lower Zone

In the Lower Zone the situation is entirely different. Stability (and some conservation) has to be achieved by the management of the environment. The Lower Zone is an area where people live and practice shifting agriculture. In current practice this leads to degradation of the environment but with modified practice can lead to environmental stability.

This offers a unique opportunity to the Carr Foundation to attempt something that has probably never been achieved over an area as large as the Lower Zone of the Study Site. With the right intentions and resources it is possible to introduce systems of settlement, farming and resource utilization which are sustainable and which require low energy input. Possible crops are vegetables including potatoes; tea, coffee and various sub tropical fruits under irrigation where appropriate. There are also ample opportunities for agro forestry with agro forestry zones strategically placed in areas more prone to erosion and which merge with existing forest and woodland.

8. Recommendations.

The following recommendations are made:

- It is considered of the utmost importance to the biodiversity of Mozambique and to the stability of water catchment areas, that all of the upper portion of the Mountain still covered with the original vegetation is maintained as a Nature Reserve. (generally land above 1100, to 1200m but in some areas below).
- Immediate measures must be put in place to prevent the cutting of forest. This is most urgent and must be vigorously pursued and supported with as many resources as possible. The most vulnerable forests are the lowermost ones on the southern and eastern slopes of the Mountain, the most remote forests in the Main Massif and on the Monte Nhassacassa Section.
- It is strongly recommended that all existing stands of original woodland be protected, even remnants. A few good stands of secondary woodland should also be protected, as both original and secondary are important to the biodiversity and for the hydrology of the Mountain.
- It is strongly recommended that all riparian vegetation along watercourses down to the base of the Mountain and beyond be protected. Where it has been destroyed it should be replanted. All woody species which naturally occur along watercourses are suitable for planting and practically all of them are easy to grow.
- It is recommended that an erosion survey be carried out. Where eroded slopes occur, stands of Acacia Karoo should be planted. This species occurs naturally on the lower slopes of the Mountain, can easily be grown from seed and produces and commercially valuable gum.
- A proposal that the boundary of the National Park should coincide with the 700m contour is strongly endorsed. It is assumed that it would be difficult to resettle the people who inhabit the areas between the 700m and 1100m contours. People living within a National Park can be better regulated as to livestock and the cutting of indigenous timber.
- The concept that the cooperation of the local population is essential for conserving biodiversity is strongly supported. This cooperation must be secured by giving local people alternatives that compensate them for what they lose.
- The preparation of a comprehensive Land Use Plan for the Lower Zone is strongly recommended. The plan should be based on a survey which aims at defining homogenous environmental units (a soil survey with inputs from a vegetation survey) on securing adequate public awareness and participation and also on solid market research. The plan should make provision for modified systems of Land Use and settlement, for sustainable agriculture and agro forestry and take the maintenance of the natural biodiversity into account wherever possible.
- It is strongly recommended that the number of cattle allowed in the Lower Zone is strictly controlled. Too many cattle cause horrendous erosion on mountain slopes.
- It is strongly recommended that the Land Use Plan and suggested developments for the Lower Zone of the Study Site, is extended down to the base of the Mountain. It would be disastrous to have a stable upper mountain and an unstable base.

The recommendations above refer in turn to the Upper Zone, the Lower Zone and the base of the Mountain. A particular recommendation is made for the boundary between the Upper and Lower Zones which can commence immediately.

The recommendation is for the planting of a belt of native forest pioneer species along the lower edge of the moist Evergreen Forest (effectively the boundary between Upper and Lower Zones and also the boundary of a proposed Mountain National Park). Clearing of forest has moved

upwards on the Mountain and has created a most irregular jagged and frayed forest edge. The planting of tens of thousands of trees will be needed to give a clear and tidy margin to the forest. Once the pioneer trees have grown up, the natural succession of forest development will follow. A clearly defined lower margin of the forest will mark in a conspicuous way the lower edge of the Conservation Area. In the longer term, as modified land uses commence, a band of agro-forestry can be established along and immediately below this forest margin.

Suitable pioneer species for planting are:

Albizia adianthifolia
Albizia gummifera
Anthocleista grandiflora
Cordia africana
Croton sylvaticus
Harungana madagascariensis
Ficus sur
Macaranga mellifera
Polyscias fulva
Shirakiopsis (Sapium) ellipticum

What is visualized from all these recommendations is a Mountain with a Nature Reserve in its upper part and a well planned and sustainable managed agricultural zone below. The agriculture zone would be interspersed with strategically placed areas of agro forestry and with the patches of indigenous vegetation, which still exist.

9. References

10. Appendices

Preliminary list of Pteridophyta

Belvisia spicata, a rare fern, found in *Brachystegia tamarindoides* woodland

This preliminary list, so far containing 104 taxa, has been compiled by Petra Ballings and Bart Wursten. It is based on personal findings , on records from *Southern African Ferns & Fern Allies* (J.E. Burrows, 1990), *Flora Zambesiaca part Pteridophyta* (FZ 1970). The latest nomenclature changes in *Conspectus of Southern African Pteridophyta* (J.P. Roux, Sabonet Report No.13, 2001) have been used where applicable. Where specimens were collected collection numbers are given.

Record references: BU= J.E. Burrows, BW= Bart Wursten, FZ= Flora Zambesiaca, PB= Petra Ballings, SRGH= National herbarium and Botanic Garden Harare, Zimbabwe.

All species are listed alphabetically by family and genus.

FAMILY/ GENUS/SPECIES	COLL.NO.	RECORDS
Family Anemiaceae [Schizaceae]		
Genus Mohria *Sw.*		
Mohria lepigera *(Baker) Baker*		FZ, SRGH
Mohria nudiuscula *J.P.Roux*		SRGH
Mohria vestita *Baker*	Ballings 435	PB, BU
Family Aspleniaceae		
Genus Asplenium *L.*		
Asplenium aethiopicum *(Burm.f.) Bech.*	Ballings 443	PB,BU
Asplenium anisophyllum *Kunze*	Ballings 422	PB,BU, SRGH
Asplenium blastophorum *Hieron*	Ballings 460	PB, BU
Asplenium christii *Hieron*	Ballings 498	PB, BU
Asplenium dregeanum *Kunze* subsp. dregeanum	Ballings 452	PB, BU, FZ,
Asplenium erectum *Bory* ex *Willd.*	Ballings 434	PB, BU, SRGH
Asplenium flexuosum *Schrad.*	Ballings 454	PB, BU
Asplenium formosum *Willd.*	Ballings 358	PB
Asplenium friesiorium *C. Chr.*	Ballings 419	PB, BU, FZ,
Asplenium gemmiferum *Schrad.*	Ballings 418	PB, BU, SRGH
Asplenium holstii *Hieron*	Ballings 737	PB
Asplenium inaequilaterale *Willd.*	Ballings 456	PB, BU
Asplenium lobatum *Pappe & Raws.*	Ballings 450	PB, BU, SRGH
Asplenium mannii *Hook.*	Ballings 417	PB, BU
Asplenium mossambicense *Schelpe*	Ballings 430	PB, BU, FZ
Asplenium normale *D.Don*	Ballings 431	PB, BU
Asplenium preussii *Hieron* ex *Brause*	Ballings 453	PB, BU, FZ,
Asplenium protensum *Schrad.*	Ballings 416	PB, BU, FZ

Asplenium rutifolium *(P.J. Bergius) Kunze*	Ballings 357	PB, BU, SRGH
Asplenium sandersonii *Hook*.	Ballings 423	PB, BU, SRGH
Asplenium theciferum *(H.B.K.) Mett.*		
var. concinnum *(Schrad.) Schelpe*	Ballings 516	PB, BU, FZ
Asplenium torrei *Schelpe*	Ballings 499	PB, BU, FZ,

Family Blechnaceae

Genus Blechnum *L.*

Blechnum attenuatum (*Sw.) Mett*	Ballings 415	PB, BU
Blechnum capense *Burm.f.*	Ballings 579	PB, BU, FZ
Blechnum tabulare (*Thunb.) Kuhn*	Ballings 466	PB, BU, FZ

Family Cyatheaceae

Genus Cyathea *Sm.*

Cyathea dregei *Kunze*	Ballings 465	PB, BU, FZ

Family Dennstaedtiaceae

Genus Blotiella *R.M. Tryon*

Blotiella glabra *(Bory) R.M. Tryon*	Ballings 414	PB, BU, FZ
Blotiella natalensis *(Hook.) R.M. Tryon*	Ballings 565	PB, BU

Genus Hypolepis *Bernh*.

Hypolepis sparsisora *(Schrad.) Kuhn*	Ballings 484	PB, BU, SRGH

Genus Pteridium *Gled. ex Scop.*

Pteridium aquilinum *(L.) Kuhn* subsp. aquilinum	Ballings 501	PB, BU, FZ

Family Dryopteridaceae [Aspidiaceae]

Genus Didymochleana *Desv*.

Didymochlaena truncatula *(Sw.) J. Sm.*	Ballings 445	PB, BU

Genus Dryopteris *Adans*.

Dryopteris inaequalis (Schltr.) Kuntze	Ballings 532	PB
Dryopteris kilemensis (*Kuhn) Kuntze*		BU, FZ
Dryopteris manniana *(Hook.) C. Chr.*	Ballings 441	PB, BU

Genus Polystichum *Roth*

Polystichum zambesiacum *Schelpe*	Ballings 403	PB, BU, SRGH

Family Gleicheniaceae

Genus Gleichenia *Sm*.

G. umbraculifera *(Kunze) T.Moore*	Ballings 574	PB

Family Grammitidaceae

Genus Grammitis *Sw*.

Grammitis nanodes *(Peter) Ching*	Ballings 529	PB, BU, FZ
Grammitis oosora *(Baker) J.E.Burrows*	Ballings 581	PB

Family Hymenophyllaceae

Genus Cephalomanes *C. Presl.*		
C. rigidum *(Sw.) K.Iwats*	Ballings 580	PB
Genus Crepidomanes *(C.Presl) C. Presl*		
Crepidomanes borbonicum *(Bosch) J.P. Roux*	Ballings 426	PB, BU, FZ
Crepidomanes melanotrichum *(Schltdl.) J.P. Roux*		BU
Genus Hymenophyllum *Sm*.		
Hymenophyllum capense *Schrad*.	Ballings 424	PB, BU, FZ
Hymenophyllum kuhnii *C.Chr.*	Ballings 407	PB, BU, FZ
Hymenophyllum tunbridgense *(L.) Sm.*	Ballings 526	PB, BU, FZ
Genus sphaerocionium *C. Presl.*		
S. capillare *(Desv.) Copel*	Ballings 558	PB
S. splendidum (*Bosch) Copel*	Ballings 425	PB, BU
Genus Trichomanes *L*.		
Trichomanes erosum *Willd.* var. aerugineum	Ballings 427	PB, BU
Trichomanes erosum *Willd*. var. erosum	Ballings 429	PB, BU

Family Lomariopsidaceae

Genus Elaphoglossum *Schott ex J.Sm.*		
Elaphoglossum acrostichoides (*Hook.& Grev.) Schelpe*	Ballings 464	PB, BU, FZ
Elaphoglossum aubertii (*Desv.) T. Moore*	Ballings 412	PB, BU, FZ
Elaphoglossum chevalieri *Christ*		BU, FZ
Elaphoglossum hybridum (*Bory) Brack.*	Ballings 411	PB, BU, FZ
Elaphoglossum lastii (*Baker) C. Chr.*	Ballings 517	PB, BU, FZ
Elaphoglossum macropodium *(Fée) T. Moore*	Ballings 413	PB, BU
Elaphoglossum spathulatum (*Bory) T.Moore*	Ballings 402	PB, BU, FZ
Genus Lomariopsis *Fée*		
Lomariopsis warneckei *(Hieron.) Alston*	Ballings 444	PB, BU

Family Lycopodiaceae

Genus Huperzia *Bernh*.		
Huperzia dacrydioides *(Baker) Pic. Serm.*	Ballings 459	PB, FZ
Huperzia gnidioides *(L.f.) Trevis.*	Ballings 437	PB, BU, FZ
Huperzia ophioglossoides *(Lam.) Rothm.*	Ballings 588	PB, BU, FZ
Huperzia phlegmaria *(L.) Rothm.*	Ballings 582	PB
Huperzia verticillata *(L.f.) Trevis.*	Ballings 410	PB, BU, FZ
Genus Lycopodiella *Holub*		
Lycopodiella sarcocaulon *(A.Braun & Welw. ex Kuhn) Pic. Serm.*	Ballings 513	PB, FZ
Genus Lycopodium		
Lycopodium clavatum *L.*	Ballings 530	PB

Family Lygodiaceae [Schizaceae]

Genus Lygodium *Sw*.
Lygodium kerstenii *Kuhn* PB

Family Marattiaceae

Genus Marattia *Sw*.
Marattia fraxinea *Sm.* Ballings 448 PB, BU

Family Oleandraceae [Davalliaceae]

Genus Arthropteris *J.Sm*
Arthropteris monocarpa (*Cordem) C.Chr.* Ballings 347 PB, BU, FZ,
Arthropteris orientalis (*J.F.Gmel.) Posth.* var. orientalis Ballings 731 PB, BU, FZ

Genus Oleandra *Cav*.
Oleandra distenta *Kunze* Ballings 438 PB, BU, FZ

Family Osmundaceae

Genus Osmunda *L.*
Osmunda regalis *L.* Ballings 355 PB, BU, FZ,

Family Polypodiaceae

Genus Belvisia *Mirb*.
Belvisia spicata *(L.f.) Mirb.* Ballings 739 PB, BU, FZ

Genus Lepisorus *(J.Sm.)Ching*
Lepisorus excavatus *(Bory ex Willd.) Ching* Ballings 489 PB, BU, FZ
Lepisorus schraderi *(Mett.) Ching* Ballings 523 PB, BU, FZ

Genus Loxogramma *(Blume) C.Presl.*
Loxogramma abyssinica *(Baker) M.G. Price* Ballings 409 PB, BU, FZ

Genus Pleopeltis *Humb. & Bonpl.* ex *Willd.*
Pleopeltis macrocarpa *(Bory ex Willd.) Kaulf.* var. macrocarpa Ballings 406 PB, BU, FZ

Genus Pleopodium *Schelpe & N.C. Anthony*
Pleopodium simianum *Schelpe & N.C. Anthony* BW

Genus Microsorum *Link*
Microsorum punctatum *(L.) Copel* Ballings 354 PB
Microsorum scolopendria *(Burm. f.) Copel* Ballings 735 PB, SRGH

Genus Polypodium *L.*
Polypodium polypodioides *(L.) Watt*
subsp. ecklonii *(Kunze) Schelpe* Ballings 732 PB, BU, FZ,

Genus Pyrrosia *Mirb*.
Pyrrosia rhodesiana *(C. Chr.) Schelpe* Ballings 405 PB, BU, SRGH
Pyrrosia schimperiana *(Mett.* ex *Kuhn) Alston* var. schimperiana BU

Family Pteridaceae [Adiantaceae]

Genus actiniopteris *Link*		
Actiniopteris dimorpha *Pic. Serm*	Ballings 687	PB
Genus Cheilanthes *Sw*.		
Cheilanthes inaequalis *(Kunze) Mett.*		
var. buchananii *(Baker) Schelpe*		BU, FZ
Cheilanthes multifida *(Sw.) Sw.*	Ballings 500	PB
Cheilanthes quadripinnata *(Forssk.) Kuhn*	Ballings 752	PB, BU, FZ
Cheilanthes viridis *(Forssk.) Sw.*		
var. glauca *(Sim) Schelpe & N.C. Anthony*	Ballings 688	PB
Cheilanthes viridis *(Forssk.) Sw.* var. viridis		PB
Genus Pellaea *Link*		
Pellaea doniana *J. Sm.* ex *Hook.*	Ballings 746	PB
Genus Pteris *L.*		
Pteris catoptera *Kunze* var. catoptera	Ballings 447	PB, BU, SRGH
Pteris muricella *Fée*	Ballings 449	PB, BU

Family Selaginellaceae

Genus Selaginella *Beauv*.		
Selaginella kraussiana *(Kunze) A. Br.*	Ballings 401	PB, BU
Selaginella mittenii *Baker*	Ballings 408	PB
Selaginella tenerrima *A. Braun* ex *Kuhn*		FZ

Family Tectariaceae [Aspidiaceae]

Genus Tectaria *Cav*.		
Tectaria gemmifera (*Fée) Alston*	Ballings 451	PB, BU

Family Thelypteridaceae

Genus Thelypteris *Schmidel.*		
Thelypteris gueinziana *(Mett.) Schelpe*		FZ, SRGH
Thelypteris madagascariensis *(Fée) Schelpe*	Ballings 586	PB
Thelypteris sp. (fronds tuffed)	Ballings 351	PB
Thelypteris sp. (creeping rhizome)	Ballings 710	PB

Family Vittariaceae

Genus Vittaria *Sm.*		
Vittaria guineensis *Desv.* var. orientalis *Hieron.*	Ballings 455	PB, BU, FZ
Vittaria isoetifolia *Bory*	Ballings 400	PB, BU, FZ
Vittaria volkensii *Hieron* var. volkensii	Ballings 436	PB, BU, FZ

Family Woodsiaceae

Genus Diplazium *Sw*.		
Diplazium nemorale *(Baker) Schelpe*	Ballings 446	PB, BU