Government of the Republic of Mozambique
Government of the Republic of Zimbabwe
Swedish International Development Cooperation Agency (Sida)

DEVELOPMENT OF THE PUNGWE RIVER BASIN JOINT INTEGRATED WATER RESOURCES MANAGEMENT STRATEGY

MONOGRAPH REPORT

ANNEX X

SECTOR STUDY ON:

CONSERVATION AREAS, WILDLIFE AND TOURISM

FINAL REPORT
APRIL 2004

SWECO & Associates

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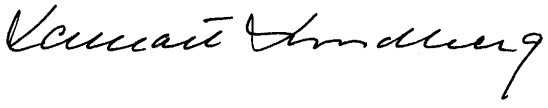

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The Pungwe Project

The Pungwe River Basin Joint Integrated Water Resources Management Strategy (IWRMS), the Pungwe Project in short, is a co-operative effort by the Governments of Zimbabwe and Mozambique to create a framework for the sustainable and equitable management, development and conservation of the water resources of the Pungwe River basin, with the objective of increasing the derived social and economic benefits for the people living in the basin. A key element in the development of this strategy by the Project lies in building capacity for its implementation and upgrading, to facilitate effective participatory management by both the authorities and stakeholders. The Pungwe River is in a shared watercourse between the two countries.

The Pungwe Project is financed by the Swedish International Development Co-operation Agency (Sida), through an agreement with Zimbabwe and Mozambique.

The project is implemented under the auspices of the Department of Water Development (DWD), in the Ministry of Rural Resources, Water Development and Irrigation (MRRWD&I), Zimbabwe, and the National Directorate of Water (DNA), in the Ministry of Public Works and Housing, Mozambique, on behalf of the two governments. The implementing agencies are the Zimbabwe National Water Authority (ZINWA) through the Save Catchment Manager's Office, and the Regional Water Administration of Central Mozambique (ARA-Centro), respectively.

The Pungwe project commenced in February 2002 and is being implemented in four phases, viz:

Phase 0 – Inception Phase

Phase 1 – Monograph Phase

Phase 2 – Scenario Development Phase

Phase 3 – Joint IWRM Strategy Phase

The Monograph Phase

During the monograph phase a large effort by the Consultant together with the implementing agencies in Zimbabwe and Mozambique was directed towards improving the knowledge base for the development of the water resources of the basin through a number of sector studies. The sector studies describe the present situation in the basin with regards to water resources, environment and pollution, water demand, infrastructure and socio-economy.

Activities to assess and strengthen the legal and institutional capacities of the implementing agencies have also been carried out. These activities that are an on-going process throughout the Project have, among others, included the development, technology acquisition and training in the use of GIS and hydrological modelling management tools.

Dissemination of information about the Project as well as consultations with stakeholder groups in the basin have been carried in order to increase the awareness of the Project and to facilitate stakeholder participation in IWRM of the Pungwe river basin.

List of Documents

The Monograph Report includes the following documents:

Main Report

Annex I Sector study on: **Surface Water Resources**

Annex II Sector study on: **Hydrometric Networks**

Annex III Sector study on: **Hydrological Data Quality & Modelling**

Annex IV Sector study on: **Groundwater Resources**

Annex V Sector study on: **Dams and other Hydraulic Works**

Annex VI Sector study on: **Water Quality and Sediment transport**

Annex VII Sector study on: **Water Demand for Water Supply & Sanitation**

Annex VIII Sector study on: **Water Demand for Irrigation and Forestry**

Annex IX Sector study on: **Fisheries**

Annex X Sector study on: **Conservation Areas, Wildlife and Tourism**

Annex XI Sector study on: **Infrastructure**

Annex XII Sector study on: **Socio-economy**

TABLE OF CONTENTS

1 EXECUTIVE SUMMARY

1.1 Main vegetation and habitats within the Pungwe River basin

At a broad level, 17 vegetation types (including mangroves) can be mapped in the Pungwe River basin of which miombo woodland is dominant covering approximately 50% of the basin. Mapped vegetation types of conservation concern that are directly reliant on regular water flow are as follows:

- The seasonally-inundated Gorongosa "tandos" that links the Zambezi Valley with the Pungwe system in the south via the Urema trough (Rift Valley);
- The seasonally inundated grasslands of the lower Pungwe/Buzi floodplains comprising approximately 4 500 km^2 of wetlands;
- The estuarine mangroves.

These wetlands are of critical importance providing a myriad of habitats for fauna, some of which are endemic and/or of threatened.

There are many smaller (but important) vegetation types/habitats dependent on rivers or streams that cannot be mapped at this broad scale, most notably Riverine Forest and Montane/Sub-montane vleis and dambos.

1.2 Protected conservation areas

The two main protected conservation areas (PCAs) within the Pungwe River basin are Gorongosa National Park (GNP) in Mozambique, covering 20% of the Pungwe River basin, and Nyanga National Park in Zimbabwe (occupying less than 1% of the basin). In Mozambique coutadas (controlled hunting areas) occupy a further 20% of the basin.

Gorongosa National Park is wholly located within the Urema trough. Several rivers flow into the Park from adjacent higher ground resulting in the extensive wetlands (the "tandos") that provide variety of habitats for wildlife. Lying at the centre of GNP is Lake Urema, which is the intermediate recipient of almost all the Urema catchment drainage, which then passes on down the Urema River to the Pungwe River. The timing of water flow on to the floodplain and its eventual departure is crucial to maintaining the Gorongosa floodplain in a condition that supports varied, and potentially abundant, wildlife. An insufficient volume of water from the catchment or too rapid an outflow will result in a drier floodplain and subsequent changes in its habitats and fauna.

1.3 Wildlife

Large mammals are mainly restricted to Protected Conservation Areas. Forty-six mammals have been recorded in GNP although four species are believed to be locally extinct (white rhino, cheetah, roan and tsessebe). Prior to the armed conflict (1980 to 1992) the GNP floodplain supported more than five tons animal biomass per km^2 (mainly large ungulates).

The most important area for aquatic birds outside of PCAs is the lower Pungwe/Buzi floodplains that support several bird species with threatened global concern status including the Wattled cranes, Woolynecked stork, Saddlebilled stork and Caspian tern. Of special interest is the Wattled Crane, a globally endangered resident of sub-Saharan Africa. Wattled cranes are believed to migrate between the Pungwe floodplains and the GNP and Zambezi Delta floodplains. In undisturbed floodplain systems the breeding cycle of Wattled Cranes is intimately linked to the natural flood cycles of rivers. Wattled Crane pairs are “triggered” to nest at peak flooding to ensure that nests are protected from predators and wildfires. As floodwaters slowly recede, Wattled Cranes raise their single chick on the pulse of exposed plant and insect life.

The only known endemic vertebrates in the Pungwe River basin are the Pungwe worm snake (occurring in the Pungwe/Buzi floodplains) and three fish species (the Gorongosa kneria, the Pungwe chiselmouth and the Beira killifish).

1.4 Tourism

Tourism in Zimbabwe is much more developed compared to Mozambique. This situation is due to the long period of armed conflict (1980-1992) in Mozambique during which there was an almost total absence of tourism. Within the Mozambican portion of the Pungwe River basin the Beira area is by far the most developed with regards to tourism: 757 guest beds are registered with the Ministry of Tourism for the Beira area out of a total of 1297 beds for the entire Pungwe River basin area. Although per capita water use by tourists is usually high (c. 500 litres or $0.5m^3$ per guest night), water consumption by tourists in the Beira accounts for less than 1% of the water supplied to the city.

1.5 Impacts of developments on conservation areas

CAs in Mozambique occur several hundred kilometres downstream from the source of the Pungwe River (e.g., the lower Pungwe/Buzi floodplains) or are dependent on water flow from major tributaries of the Pungwe River (e.g., GNP floodplains). Interventions that alter seasonal flow or reduce flow could impact adversely on the floodplains and, in the case of GNP, reduce its potential to provide benefits through non-consumptive tourism.

There are two specific proposed interventions that may impact directly upon water flow in the Pungwe River *viz.,* the Bué Maria Dam on the Pungwe River and a small dam on the Nhandare River, a tributary of the Pungwe. Neither is likely to significantly affect the GNP floodplains *per se*. However, the Bué Maria Dam is likely to affect the Pungwe riverine vegetation immediately downstream (which forms the southern boundary of GNP) and, more importantly, the lower Pungwe/Buzi floodplains.

A two-level approach is recommended for determining potential impacts on CAs: an initial screening and an EIA proper. If an initial screening indicates that impacts may be serious, a full EIA would then be carried out, in which the effects of the intervention are subjected to greater scrutiny. A suggested checklist for use at both levels is included as an Appendix to this report.

2 INTRODUCTION

2.1 Background

This Annex provides the current status of conservation areas, wildlife and tourism within the Pungwe River basin.

Mozambique's flagship protected conservation area (Gorongosa National Park – GNP) occurs entirely within the Pungwe River basin. It covers nearly 20% of the surface area of the basin. There are also several controlled hunting areas (coutadas) that occur within, or partially within the Mozambican portion of the Pungwe River basin. In total these conservation areas cover approximately 40% of the Pungwe River basin. In Zimbabwe, Nyanga National Park falls partially within the Pungwe River basin and occupies a relatively small area of the overall basin although it is an important tourism destination.

Wildlife (large mammals) is mainly restricted to the protected conservation areas. Wildlife populations in GNP and surrounding areas were decimated during the armed conflict (1980-1992) and numbers have only started to increase in recent years. The wildlife in GNP is largely reliant on the floodplains occurring within the park. These floodplains are themselves dependent on runoff from the Urema sub-catchment within the Pungwe River basin. The lower Pungwe floodplains cover a vast area (including the Pungwe estuary) and are important for aquatic birds.

The recently passed Mozambican National Tourism Policy (2003) recognizes national parks as potential destinations for tourism (contingent upon effective management and the increase in number of large mammals). GNP is, therefore, important for biological conservation as well as for potential income generation from tourism.

Nyanga National Park (and surrounding areas with spectacular scenery) has long been a favoured destination for Zimbabwean and international tourists. However, the number of tourists visiting Zimbabwe has declined significantly in recent years due to the political and economic situation.

2.2 Study objectives

The main objectives of this sector study are as follows:

1. To provide a broad overview of the principal habitats and vegetation types occurring within the Pungwe River basin.

2. To identify and document all conservation areas and associated wildlife occurring within the basin.

3. To describe wetland habitats that are dependent upon a continued and regular flow of the Pungwe River.

4. To assess the water requirements for the ecosystems and conservation areas.

5. To identify and document other important wildlife areas occurring outside of conservation areas.

6. To describe any rare or restricted range plant and/or animal species whose habitat may depend upon a continued and regular flow of the Pungwe River and its tributaries.

7. To identify existing and potential tourism areas within the basin and assess their water demand.

8. To identify and evaluate potential impacts on conservation areas and other wildlife habitats that may arise from development projects.

3 VEGETATION TYPES AND HABITATS IN THE PUNGWE RIVER BASIN

3.1 Overview of main vegetation types in the Pungwe River basin

At a broad level of mapping at least 15 vegetation types and one anthropogenic habitat can be mapped[1] (see **Figure 1**); due to their relatively small size mangroves are mapped separately (see **Figure 2**). The mapping units are based mainly on Wild and Barbosa (1967). In the Pungwe River basin miombo woodland[2] is the main vegetation type covering c. 50% % of the basin. Several different types of miombo occur in the Pungwe River basin distinguished on the basis of structure (height, density, etc), species composition (although the presence of *Brachystegia* spp. and/or *Julbernardia* sp. is a necessary criteria for classifying the woodland as miombo) and phenology.

The vegetation types directly reliant on water run-off in the basin are the vegetation on Alluviums (comprising (a) the seasonally-inundated Gorongosa "tandos" that links the Zambezi Valley with the Pungwe system in the south via the Urema trough (Rift Valley) and (b) the seasonally inundated grasslands of the lower Pungwe/Buzi floodplains and estuary) and Mangroves (15 and 16 respectively below). Gorongosa National Park is located within the Urema trough and the importance of the Gorongosa "tandos" for wildlife is more fully discussed in chapter 4.3.

A map showing the distribution of the broad vegetation types is shown in **Figure 1** below.

The vegetation of the Zimbabwean portion has been mapped and described in more detail and this is given a separate Appendix (**Appendix 1**).

[1] There are many other vegetation types or habitats e.g., fringing riverine forests, marshes, vleis/dambos, rocky outcrops/koppies etc. that occur within the overall broad vegetation types; these cannot be mapped at this scale but where relevant are highlighted in the text.

[2] In southern Africa, the main savanna (woodland) type is miombo and refers to woodland types dominated by members of the genus *Brachystegia* and/or closely related genera such as *Julbernardia*.

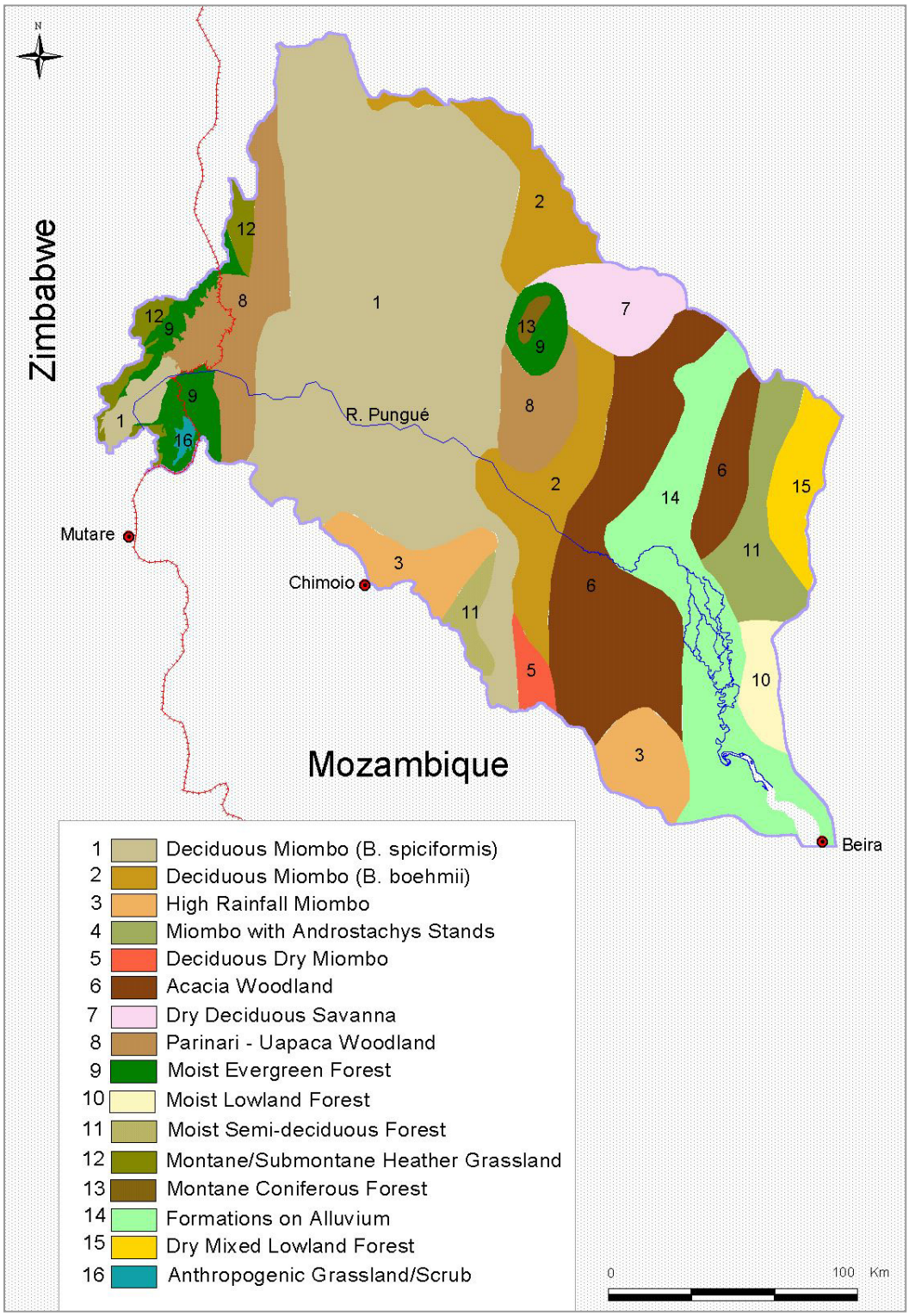


Figure 1 Main vegetation types in the Pungwe River basin (after Wild and Barbosa, 1967)

1. Semi-Moist Deciduous Miombo-Median Altitude

Brachystegia spiciformis-Julbernardia globiflora savanna woodland is very important on the plateaux of Manica and Sofala Provinces covering the zone between 600 and 900 m altitude. It forms a broad belt in the Alto Pungwe River basin north of Chimoio. It occurs on a great variety of soils derived from, for example, granites, gneisses, Umkondo sandstones, quartzites and schists. The rainfall is about 700 to 1 200 mm per annum. Above 1 000 m, or in somewhat wetter parts, it is replaced by semi-deciduous high rainfall miombo of *Brachystegia spiciformis*.

2. Deciduous Miombo (North-Eastern Lowland and Escarpment Savanna Woodland)

In Mozambique this type of vegetation is abundant in Manica and Sofala Provinces. Soils are derived from the granite-gneissic complex, shallow and stony.

The trees are of medium or small height and include Brachystegia boehmii, Julbernardia globiflora, Burkea africana, Pseudolachnostylis maprouneifolia, Crossopteryx febrifuga, Diplorhynchus condylocarpon, etc.

3. High Rainfall Miombo Woodland *Brachystegia spiciformis*

High rainfall miombo occurs on the Chimoio plateau and a small area of this type of woodland occupies the Pungwe River basin north Chimoio/Gondola. It occurs generally in red, clayey, ferralitic soils derived from granite or gneisses with a rainfall of 1 200 to 1 500 mm per annum.

4. Deciduous Miombo Tree Savanna with Gregarious Dense Dry Woodland: *Julbernardia globiflora-Androstachys johnsonii*

There is belt of this woodland type occurs between Inhaminga and the Urema River lowland that intrudes into the eastern Pungwe River basin. This woodland consists of species such as *Julbernardia globiflora, Pterocarpus angolensis, Burkea africana, Albizia versicolor and Afzelia quanzensis.* Gregarious patches of *Androstachys johnsonii* forest form a further element of the mosaic.

5. Dry Deciduous Miombo - Julbernardia globiflora

Dry deciduous miombo comprising mainly *Julbernardia globiflora* occurs in the south of the Pungwe River basin between Beira and Chimoio.

6. *Acacia* Woodland

There is an extensive area of *Acacia* woodland running approximately in a north-east direction through the Pungwe River basin (Manica and Sofala Provinces). The *Acacia* woodland comprises communities of scattered trees and shrubs where *Acacia nigrescens* is the dominant in the tree/shrub layer.

An important patch extends northwards on the slopes of the lowland "tandos" of the R. Urema (Gorongosa) towards the Zambezi Valley. It occurs on soils derived from basalt which are generally shallow or skeletal, black and heavy, or, from Cretaceous to recent deposits with sandstones and conglomerates. They are sometimes calcareous and more rarely somewhat saline. The rainfall is about 500-1 000 mm and very variable. The appearance of this savanna is somewhat xeromorphic.

7. Dry Deciduous Tree or Shrub Savanna (Sub-Planaltic): Adansonia, Sterculia-Acacia nigrescens, Pterocarpus brenanii Diplorhynchus

This type is confined to Mozambique in an area between 200 and 400 m altitude situated between the Zambezi on the northeast, the Chiramba valley to the north and the Urema valley to the southeast. This type occupies in a small area of the Pungwe River basin running northeast from Gorongosa Mountain.

8. Semi-Evergreen High Rainfall Tree Savanna **–** *Parinari-Uapaca*

Parinari curatellifolia is evergreen or practically so. *Uapaca* species occurring in the association may include *U. kirkiana, U. nitida* and *U. sansibarica.* In the Pungwe River basin this type occurs to the south of Gorongosa Mountain and across the Mozambican-Zimbabwean border. In the Zimbabwean portion much of valleys floor vegetation has been transformed by human use. It appears between 900 and 1 500 m in ferralitic, red, clayey soils. It is usually correlated with rainfalls of about 1 000-1 500 mm per annum.

9. Moist Evergreen Forest (Cassipourea, Aphloia, Macaranga)

Two relict areas of this type exist in the Pungwe River basin: the first patch occurs on the Gorongosa Mountain and the second, larger area, occurs across the Mozambican-Zimbabwean border on the slopes and gullies of the Inyanga Mountains. The rainfall is about 1 500 to 1 800 mm p.a.

The higher levels in this zone is usually characterized by a combination of *Cassipourea malosana, Nuxia congesta, Podocarpus latifolius* and the sub-canopy species *Aphloeia theiformis*.

Other common trees are Kiggelaria africana, Curtisia dentata, Ilex mitis, Maesa lanceolata, Macaranga mellifera and Schefflera umbellifera.

At medium altitude levels Cassipourea gummiflua and Chrysophyllum gorungosanus occur.

10. Moist Lowland Forest/Woodland: Pteleopsis myrtifolia-Erythrophleum suavelons- Brachystegia

Mixed formations of dense semi-deciduous tall forest of *Pteleopsis myrtifolia-Erythrophleum suavelons* with *Hirtella zanguebarica*; forming a mosaic with *Brachystegia spiciformis-Julbernardia globiflora* woodland occupy the sublittoral zone from Beira (Cheringoma) to Inhaminga and Marromeu in the north. Only a small extent occurs within the eastern Pungwe River basin.

This type develops in these areas because of the relatively abundant littoral rains and also because of the accumulation of ground water. It is partially, therefore, edaphically controlled.

11. Moist Semi-Deciduous Forests of the Mesoplanaltic Slopes and Lowlands western Mozambique): *Newtonia, Pteleopsis myrtifolia* and *Erythrophleum*

The altitudinal range is from 600-1 200 m and the forests mainly occur southeast of the Chimoio plateaux intruding into the Pungwe River basin in the south. Rainfall is approximately 1 000-1 200 mm per annum.

The dominant species are *Newtonia buchananii, Erythrophleum suaveolens*, *Pteleopsis myrtifolia, Khaya nyasica* (much exploited) and *Ekebergia capensis.* When this forest if of a secondary type it develops a dense shrub layer with many species such as *Harungana madagascariensis, Macaranga capensis* and *Albizia adianthifolia.*

Within the Mozambican portion of the Pungwe River basin this forest type has been much exploited due to the proximity of the Beira corridor.

Newtonia buchananii forest occurred in the valley floor of the Zimbabwean portion of the Pungwe River basin but was felled and burned in the mid-1950s and now comprises only a very small remnant.

12. Submontane and Montane Heather-Grassland

The high mountain ranges, at altitudes over 1 600 m along the Mozambique-Zimbabwe border are characterised by montane grassland which is fire maintained. Main species are *Themeda* sp. on the clay soils and *Loudetia* sp. on the sandier soils.

Protea welwitschii and *P.* (*caffra* ssp.) *gazensis* may occur on higher rocky slopes. On the hillsides the heather *Blaeria friesii* forms patches within low bushes of *Helichrysum splendidum* and *H. mimetes.*

13. Montane Conifer Forests: Widdringtonia, Podocarpus or Jumiperus

Forests of sclerophyllous type with a dominance of gymnosperms such as *Widdringtonia nodiflora, Podocarpus milanjianus* and *Juniperus procera* occur on the southeast slope near the top of the Gorongosa Mountains.

In Zimbabawe, *Widdringtonia nodiflora* forest is very limited in the Eastern District mountains, and is found between 1 700 and 2 100 m along rocky streams in valleys in rain-shadow areas (not mapped in **Figure 1**).

14. Vegetation on Alluviums

This is mapped as a single unit although two main sub-units can be distinguished *viz.,* (a) the seasonally-inundated Gorongosa "tandos" that links the Zambezi Valley with the Pungwe system in the south via the Urema trough (Rift Valley) and (b) the seasonally inundated grasslands of the lower Pungwe/Buzi floodplains and estuary.

(a) The seasonally-inundated Gorongosa "tandos" of the Urema trough

A large extent of this seasonally–inundated lowland formation (the Gorongosa "tandos") links the Zambezi Valley with the Pungwe system in the south via the Urema trough (Rift Valley). The "trough" is inundated during the wetter seasons. This formation comprises extensive grasslands ("tandos") with a large number of pools in lower lying areas, tree and scrub savanna (including palm savanna) and thicket, riverine and dry forest and aquatic herb communities.

This type is characteristic of an area in the Gorongosa National Park in the valleys of the R. Urema and its tributaries and is discussed in more detail in Chapter 4.

(b) The inundated grasslands of the lower Pungwe/Buzi floodplains and estuary

Three main subtypes can be distinguished:

- **Subtype 1:** *Aquatic vegetation in the rivers:* approaching the coast the Pungwe River meanders through a broad floodplain via many channels and delta arms. Where the river flow is slow floating aquatic vegetation may develop (e.g., *Pistia stratoides*) similar to that common in lagoons and lakes. In addition, *Cyperus papyrus*, *Typha latifolia* and *Nymphaea lotus* are common in meandering channels and delta arms.

- **Subtype 2:** *Inundated Grasslands:* Moist grasslands cover extensive areas of the Pungwe floodplain; *Setaria* spp. such as *S. holstii* (sometimes dominant), *S. mombassana, S. sphacelata* and *Ischaemum*

afrum (very common*), I. arcuatum, Bothriocloa insculpta, Echinochloa spp., urochloa mosambicensis, Sorghum spp., Panicum coloratum, Hermarthria altissima, Paspalum commersonii,* etc. These grasslands are mapped in more detail in **Figure 2**.

At the edges of water channels Cynodon dactylon and Chloris gayana are abundant and sometimes Oryza barthii, Leersia hexandra, Sacciolepis africana (R. Pungwe), Brachiaria brizantha, Brachiaria spp., Eriochloa meyeriana, Coelorhachis capensis, Hemarthria altissima and Paspalum vaginatum. The last four grass species mentioned are also salt tolerant.

- **Sub-type 3:** *Tree/shrub savanna* - in these alluvial areas the higher and better drained zones may have a tree/shrub savanna with low or medium height grass layer. The grasses mainly belong to the Paniceae and form good "sweet" pastures. The trees and shrubs are rather widely spaced.

  Acacia species usually predominant in these savannas with *Acacia polyacantha* subsp. *campylacantha* often dominant with *A. nilotica* subsp. *kraussiana* in badly drained soils, and *A. xanthophloea* (the "fever tree") in dark wet soils.

  Intergrading with the savanna near swampy depressions or around lagoons are palm communities with *Borassus aethiopum*, *Hyphaene crinita*, *H. coriacea* or *Phoenix reclinata*.

15. Mosaic of low altitude dry (mixed) forest and miombo woodland, *Adansonia-Cordyla; Brachystegia; Pteleopsis-Erythrophleum*

The Inhaminga plateau mosaic occurs in the higher parts between Muanza and Inhaminga in sandy soils derived from sandstone and Quaternary sands. Here are found tall semi-evergreen forest patches of *Pteleopsis* and *Erythrophleum* mixed with woodland of *Brachystegia spiciformis-Julbernardia globiflora*. In more localised areas there is dense deciduous forest of *Adansonia, Bombax rhodognaphalon*, *Chlorophora excelsa* and *Millettia stuhlmannii* or tree savanna species of a drier type such as *Ostryoderris, Sclerocarya*, *Acacia* spp., *Ziziphus*, etc. There are also dense thickets of *Grewia transzambesica, Pseudobersama mossambicensis, Popowia buchananii, Harungana madagascariensis, Londolphia kirkii, Diodia scandens, Rinorea holtzii*, etc.

16. Mangroves

Mangrove communities occur on the inter-riverine islands and mudflats of the Pungwe-Buzi estuary (**Figure 2**).

At least eleven (12) mangrove tree species occur within the estuary (**Table 1**). The most common tree species are *Rhizophora mucronata*, *Sonneratia alba*, *Bruguiera gymnorhiza, Ceriops tagal* and *Avicennia marina*.

Table 1 Mangrove tree species in the Pungwe Estuary

SCIENTIFIC NAME	LOCAL NAMES	CLASSIFICATION
Avicennia marina	Imcede; Mpedge	True mangrove species
Bruguiera gymnorhiza	M'finse	True mangrove species
Ceriops tagal	Mucandala; Nhakandala	True mangrove species
Heritiera litoralis	Mucolongo; Necolongo	True mangrove species
Lumnitzera racemosa	Piripito; Mpiripito	True mangrove species
Rhizophora mucronata	Nhantanzira	True mangrove species
Sonneratia alba	M'pia	True mangrove species
Xylocarpus granatum	Murrubo; Marrubo	True mangrove species
Thespesia tiliences	Mulola	Mangrove associate
Hibiscus tiliences	Mulolamdembe	Mangrove associate
Barringtoma racemosa	Kunli; Nkunli	Mangrove associate
Phoenix reclinata	Palm, Tchindo, Muchindo	Mangrove associate

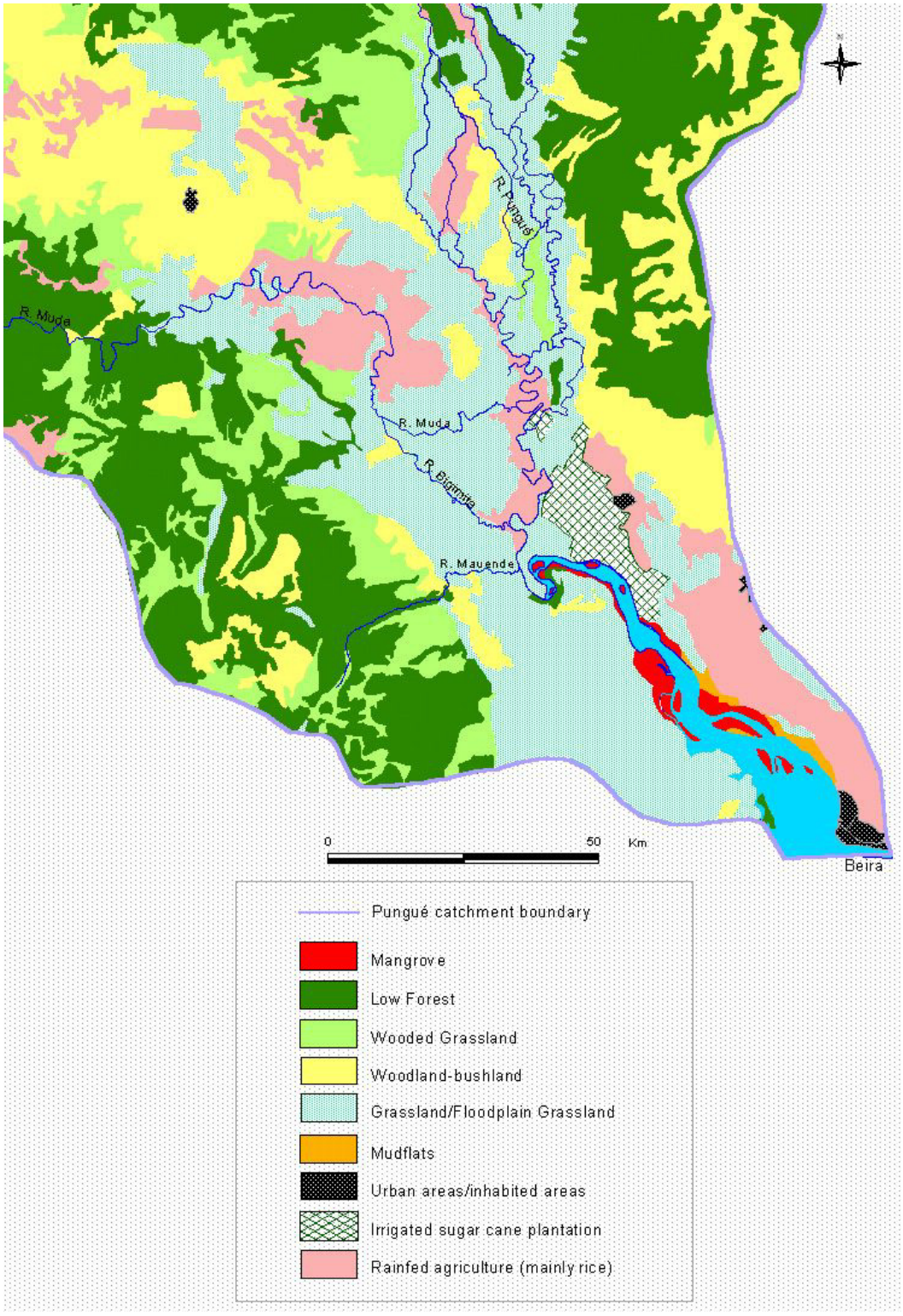


Figure 2 Mangroves and floodplain vegetation in the lower Pungwe

3.2 Important vegetation types/habitats associated with rivers and streams

The previous sub-section provides a broad overview of the main vegetation types and habitats occurring within the Pungwe River basin. Those reliant on water flow that are sufficiently large have been mapped and described *viz.* the Urema and lower Pungwe floodplains and mangroves.

However, there are many smaller vegetation types/habitats dependent on rivers or streams that cannot be mapped at this broad scale. These are described below.

3.2.1 Riverine Forest in Zimbabwe

In Zimbabwe riverine forests occur along the lower sections of the Pungwe River and its major tributaries. This forest type is characterised by large trees of *Newtonia buchananii*, *Trichilia emetica*, *Khaya anthotheca* (formerly *K. nyassica*) and *Albizia adianthifolia*. A similar narrow strip of riverine forest lines the banks of the Nyamkwarara River. On rocky stream and river-banks, *Breonadia salicina* (*Adina microcephala*) attains large dimensions, and the protected Royal Fern (*Osmunda regalis*) also occurs there. Locally common is the interesting rare climbing fern *Lygodium kerstenii* that often forms thick tangles. Tragically, most of the riverine forest in the Holdenby Communal Area in the Pungwe River basin has been destroyed during the past 20 years and maize is now grown down to the river's edge in contravention of the Natural Resources Streambank Regulations.

3.2.2 High Wetlands in Zimbabwe

High wetlands are very limited in extent to the belt between altitudes 1 600 m and 2 000m. They are ecologically very important because they support flora and fauna that is not encountered elsewhere in the basin. Regrettably, no systematic sampling appears to have been undertaken of the grasses, sedges and other plants that occur in them. The most extensive of these wetlands are those that are situated on old meanders and oxbows in the upper Pungwe River valley above its junction with the Madzimawuya and Matenderere Rivers. Some also occur in the Duru River vlei on Wattle Company land on the plateau on either side of the road to the teas tea estates. The latter was home to a pair of Wattled Cranes, as well as other uncommon birds such as Flufftails, Rails, Broad-tail Grass Warbler and Grassbird, but no survey has been undertaken of the vegetation of these either. Since the removal of cattle that were formerly allowed to graze the Duru Vlei, reeds (*Phragmites mauritianus*) have proliferated, as also has the tall grass *Pennisetum glaucocladum*, and this has made the vlei untenable for the Cranes. *Koeleria capensis* is one of the shorter grass species. On the margins of the lower end of the Duru Vlei an exceptionally tall species of Red-hot Poker (*Kniphofia*) has been found that reaches a height of over 3 m. It may be a form of *K. splendida*

but has not yet been identified. It should be of great horticultural value, and needs propagation and protection.

3.2.3 Sub-montane (Highveld) wetlands in Zimbabwe

In Zimbabwe, highveld wetlands occur in submontane areas between altitude 1 300 m and 1 600 m in high rainfall areas. These are now very reduced in extent by garden encroachment and most are now virtually non-existent due to overgrazing and resultant erosion and the lowering of the water table, especially all those in the Communal Lands. They used to be the habitat of Crowned and Wattled Cranes up till about 1960, when political and population pressures caused them to be opened up for grazing. Grasses that are frequently encountered in those vleis that have not been too severely degraded are *Acroceras macrum, Hemarthria altissima, Leersia hexandra* and *Eulalia geniculata*. The 2 m tall reedy grass *Pennisetum glaucocladum* forms thick stands in protected streambeds.

3.2.4 Bogs and Vleis in the Gorongosa Mountain in Mozambique

Around valley heads and on stream margins in the summit grasslands, are springs and oozes, which support perennial low herbaceous bog communities, generally less than 50 cm in height. Some are peat bogs dominated by patches of *Sphagnum* moss, mixed with sundews and many small mat-forming herbs of *rhizomatous*, *stoloniferous* and tufted growth form. The more seasonal bogs support pure patches of the 150 cm tall pedestalled sedge *Costularia natalensis.* The bogs are extremely acid (pH4). Sedges and small forbs predominate in each.

Some species such *as Lobelia intertexta*, which also occurs in the adjacent grasslands, flowers throughout the year. The red fire lily *Cyrtanthus tuckii* is rare and appears following fires.

3.2.5 Ravine and Riverine Forest along fast flowing streams of Gorongosa Mountain in Mozambique.

Many tree species occur in the ravine and riverine zones throughout the Gorongosa mountain area. These are composed of many rain forest and thicket species as well as those more generally confined to, or typical of, streambanks. Some of the components include: *Albizia glaberrima, Bersama abyssinica, Bombax rhodognaphalon, Craibia brevicaudata, Ficus capensis, Khaya nyassica, Pandanus* sp., *Parkia filicoidea, Raffia* sp. and *Syzygium guineense.*

The giant canopy liana *Entada pursaetha* with long pendant pods, 1.0 m to 1.5 m long, is abundant in riverine forest and its stems frequently attain a diameter of 50 cm.

3.2.6 Mid Altitude Riverine Forest and Thicket (Mozambique)

In mid-altitude areas the major rivers, especially the Pungwe and Nhandungue rivers support riverine thicket and forest.

Riverine thicket contains species such as Ficus sycamorus, Diospyros mespiliformis, Mimusops fruticosa, Trichilia emetica, Ekebergia capensis, Khaya nyasica and Kigelia africana.

Tall riverine forest occurs along much of the Pungwe and Nhandungue rivers (in the former case before it discharges into the vast Pungwe floodplain). A large patch occurs on the north bank of the Nhandungue River within Gorongosa National Park (GNP). Here a high canopy and emergent stratum of trees between 22 m and 30 m occurs with a sparse median tree layer.

Dense patches of riverine forest occur on old courses of the Pungwe River, east of Chitengo Camp (in GNP).

The most important large riverine trees include: Bombax rhodognaphalon, Cordyla africana, Diospyros mespiliformis, Ekebergia capensis, Ficus sycamorus, Khaya nyasica, Cordia goetzei, Diospyros senesis, Erythroxylum emarginatum, Lecaniodiscus fraxinifolius and Oncoba spinosa.

4 CONSERVATION AREAS

4.1 Overview

The two main protected conservation areas (PCAs) within the Pungwe River basin are Gorongosa National Park (GNP) in Mozambique and Nyanga National Park in Zimbabwe. The latter partially lies within the basin.

Other PCAs partially occurring in the Pingwe Basin in Mozambique are:

- Two "vigilance areas" to the north of GNP, the most southerly of them abutting the park. They are currently being developed for game ranching, with the intention of using them for safari hunting.

- Three controlled hunting areas (*coutadas*) in Sofala and Manica Provinces that occur within, or partly in, the Pungwe River basin. Hunting concessions are presently operational in two of them.

In Zimbabwe the other PCA within the Pungwe catchment is the 100 ha Ringing Rocks Botanical Reserve on Chingamwe Forestry Estate. Stream bank vegetation in Zimbabwe is also protected by law but this is regularly violated.

Together all categories of PCAs cover approximately 42% of the Pungwe River basin, of which the two strictly protected areas (Gorongosa National Park and Nyanga National Park) account for 20% of the basin area. The locations of the main protected conservation areas in relation to the Pungwe River basin are shown in **Figure 3**.

The management of conservation areas and associated wildlife at a national level has been much more effective in Zimbabwe compared to Mozambique. This situation is due to the long period of armed conflict (1979-1992) in Mozambique during which there was a total absence of management, and wildlife populations were decimated. Consequently, tourism based on non-consumptive use of wildlife in Zimbabwe has thrived (albeit at lower levels in recent years due to the economic and political situation in the country) whist in Mozambique this type of tourism is currently non-existent.

4.2 Institutional framework for PCA management

4.2.1 Institutional Framework in Mozambique

In Mozambique, the Ministry of Tourism, through its National Directorate of Conservation Areas (DNAC), is responsible for thr following three categories

of protected conservation areas (PCAs) in which the conservation of biodiversity is a primary objective.[3]

National park: managed for ecological, cultural, aesthetic and socio-economic purposes. No other forms of land uses are permitted under current law. There are six national parks, with a total area of 37 476 km^2, about 4.70 per cent of Mozambique.

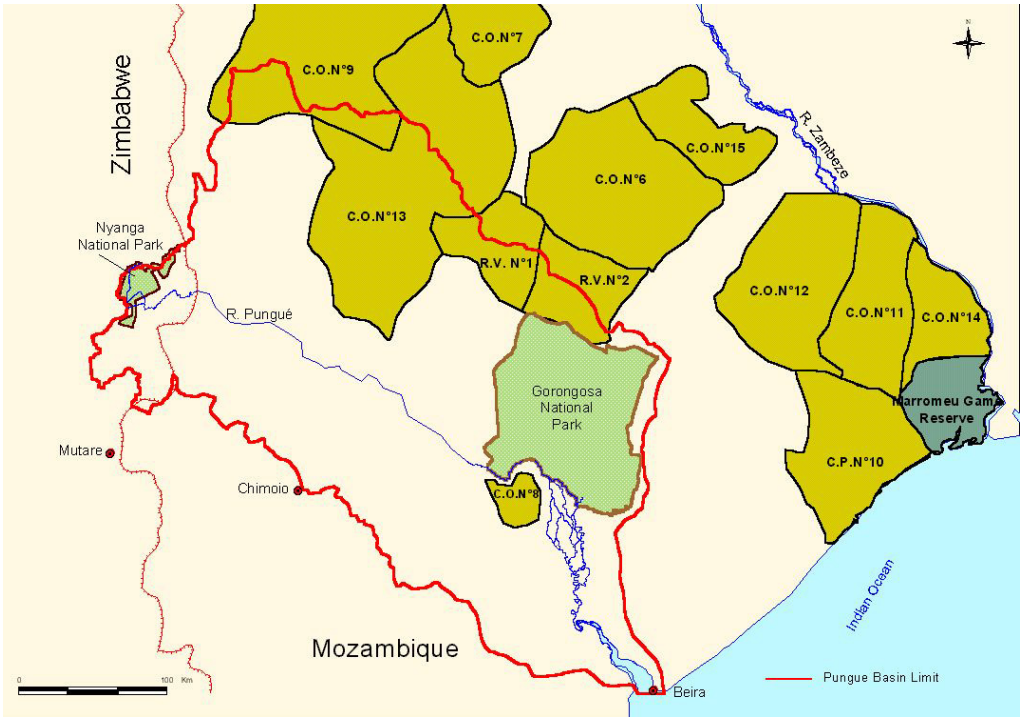


Figure 3 Location of protected areas in the Pungwe River basin (note: a portion of Nyanga National Park occurs outside the Pungwe River basin; this is not shown)

Game reserve: similar to national parks but excluding socio-economic purposes. One or more species may be specially protected.

Controlled hunting area (coutada): hunting under licence is allowed in addition to other forms of land use.

The Ministry of Agriculture and Rural Development, through its National Directorate for Forestry and Wildlife (DNFFB), is responsible for forest reserves, (including the fauna therein) as well as wildlife and forest resources outside DNAC's conservation areas.

[3] Until March 2001, the National Directorate for Forestry and Wildlife (DNFFB) was responsible for the management of all protected areas in Mozambique as well as for the management and conservation of wildlife and forestry resources outside of the protected areas network. DNFFB continues to be responsible for wildlife and forests outside of protected areas as well as the management of forestry reserves.

4.2.2 Institutional Framework in Zimbabwe

The responsibility for the protection of wild life (both flora and fauna) in Zimbabwe is vested with the recently renamed **National Parks and Wildlife Management Authority** (NPWMA) under the Ministry of Environment and Tourism. The NPWMA is headed by a Director General. An Executive Board helps to determine policy and to oversee its correct functioning.

Under the new arrangement, there are three Divisions under the Director General:

1. The Division of Management and Conservation

2. The Division of Human Resources, Finance and Administration

3. The Division of Commercial Services

The Division of Management and Conservation comprises a section with responsibilities for law enforcement and parks management, and a separate section that deals with research.

The NPWMA is still in a transitional phase and now operates under the new Parks and Wildlife Act (19: 2001). It is currently severely hampered by lack of funds and inadequate staff with only 50% of the staff establishment filled. It is required to raise its own funds for operating expenses from levied charges that are paid into the Parks and Wildlife Conservation Fund. Government funds only cover capital works.

The Authority does not appear to have any jurisdiction over the fate of flora and fauna on private land, resettlement areas or Communal Land, unless Specially Protected Species are involved. The felling of natural woodlands for production of firewood for sale, or its conversion into agricultural lands along riverbanks does not come under its control.

4.3 Protected conservation areas in Gorongosa National Park in Mozambique

4.3.1 Location and History

Gorongosa National Park (GNP), the "flagship" conservation area in Mozambique has a total area of. 5 370 km^2. It was created in 1960. The park is located wholly within the Pungwe River Basin where it occupies a significant proportion of the basin in Mozambique, approximately 18.1%. Its location with respect to the rest of the basin is shown in **Figure 1**. GNP is, therefore, the most important Protected Conservation Area (PCA) in the Pungwe River basin. The park lies within the southern-most portion of the Great Rift Valley and is bounded in the east by Gorongosa Mountain and in the west by the

Cheringoma Plateau. Several rivers flow into it from the mountain and the plateau. Consequently, the main features of GNP are the extensive wetlands that provide a variety of habitats for wildlife.

The ecological richness and biodiversity of GNP were recognized by explorers from the outside world more than a century ago, although foreign hunters had been there at least 300 years before that, and local people must have been well aware of the floodplain's significance for large wild animals long before.

A 1 000 km^2 tract of land in what is now GNP was declared a game reserve in 1921. In 1935, it was enlarged to 3 200 km^2. In 1960, it was redesignated a national park and further extended to its current size.

After GNP was established, neighbouring hunting areas (*coutadas*) benefited from the reservoir of large wild animals that thrived on the floodplain.

In 1969 Tinley recommended that, in order to secure a viable, ecologically coherent entity, parts of Gorongosa Mountain should be brought into the park including the remaining catchments that ultimately discharge on to the floodplain. This would have entailed increasing the park to about 8 200 km^2. This recommendation was not implemented.

Tinley (1977) made a detailed study of the park, and described it as it was in the 1960s and early 1970s. In the 1970s the GNP floodplain supported the most notable concentration of large wild mammals known in Mozambique. The park was famous in African conservation circles. Before the country's independence from Portugal in 1975, the park was visited each year by thousands of tourists from Rhodesia (now Zimbabwe) and South Africa, and by sport hunters from Europe and North America. It was the 'jewel in the crown' of the country's PCA system.

Since Tinley's (1977) description, circumstances have altered radically as a result of war and lawlessness, which prevailed nationwide from 1979 to 1992. For the last 10 years of that period, Frelimo and Renamo soldiers occupied the park. They hunted for rations and for ivory, and landmines were laid. When a cease-fire agreement was signed in October 1992, the soldiers were demobilized and civilians came back to find what was left to hunt. Beira region has a long-established hunting tradition (Robert Zolho, Warden of GNP, *pers com*).

Since 1997 the Government of Mozambique has been restoring GNP with support from the African Development Bank (ADB) through Gestão dos Recursos Florestais e Faunisticos Project - the GERFFA Project (the Management of Forest and Wildlife Resources Project). The forestry

component made forest inventories and defined forest concession areas. The wildlife component focused on GNP and Marromeu Game Reserve[4].

The project enabled the Government technical department to establish a presence in GNP after a long absence. Law-enforcement work got underway and people living in and around the park were made aware of this. Local markets were checked for game meat. Areas were cleared of anti-personnel and anti-tank mines. Inventory work included aerial censuses of large animals on the floodplain.

GNP will be a national asset if conditions similar to those that existed in the 1960s can be restored. The chief feature of this asset is large wild animals in variety and abundance. It is an asset that thousands of foreign visitors will pay handsomely to see; others will pay to hunt in peripheral areas around GNP. The asset is still only a potential one until full restoration is achieved.

A major factor in restoring and maintaining GNP is its hydrological status. An optimum variety and abundance of animals is reliant upon a mosaic of habitats that can only be sustained if an annual flood regime is maintained. This in turn is affected by human land uses in the park's floodplain and in its catchments.

4.3.2 Administrative Framework

From 1982 to 1992, GNP was without effective management, and its wildlife resources were plundered. After 1994, DNFFB (the sole conservation department at that time) took up the reins of management again. Today, there are 135 park personnel, of which 86 are Scouts deployed in about 20 camps around the park, from which they patrol it.

Bell and Clarke (1984) estimated that 50 km^2/scout was a rule-of-thumb target to aim for in African PCAs. More than this and staff becomes too sparse to be effective. In comparison with other similar southern African countries Gorongosa (53 km^2/scout) is somewhat under-staffed (e.g., Kenya has 20 km^2/scout and South Africa 22 km^2/scout. This report recommends an addition of 33 Scouts to bring total patrolling strength up to 119, a ratio of 45 km^2/scout.

4.3.3 Topography and Drainage

Elevation over the Gorongosa ecosystem[5] ranges from about 10 m to over 1 800 m. The GNP straddles a section of the southern end of the Great Rift Valley of East Africa. Where the rift valley crosses the Pungwe River basin, it follows a roughly north-northeast to south-southwest alignment. In this sector,

[4] Marromeu GR lies on the coast in the Zambezi delta due east of GNP but outside the *Pungwe River basin*.

[5] The Gorongosa ecosystem refers to the Gorongosa Mountain - Rift valley –Cheringoma plateau complex

the rift is quite shallow and its sides slope gently. In effect, the park spans a 40 km wide trough[6] with an alluvial floor that slopes imperceptibly from about 80 m to 12 m over a distance of 50 km—a gradient of less than 0.1%. Higher ground lies east and west. Towards the eastern boundary, the land rises to elevations of about 300 m on the Cheringoma Plateau. To the west, are the Báruè Midlands at about 400 m and Gorongosa Mountain at 1 863 m.

The GNP catchment, therefore, extends well beyond it's boundaries and includes the higher ground to the west, northwest and east. Gorongosa Mountain is an isolated massif measuring about 30 km x 20 km, with only a few kilometres outside the park. It has particular significance on the ecology of the park, and is the only eminent feature in the region that stands in the path of moisture-bearing winds. Mean annual rainfall exceeds 2 000 mm. Its rainforest, heath and montane grassland form a sponge that captures, stores and releases water at a more constant rate than other rivers in the catchment. Four of the main streams that originate in the mountain enter the Rift Valley floor within the park.

A schematic representation of the main topographic features in relation to GNP is shown in **Figure 4** below.

4.3.4 Climate

The GNP's and its catchment is tropical savannah, characterised by a moister, warmer season (October-April) and cooler, drier period (May-September). The exception is Gorongosa Mountain, where higher elevations lead to a warm, temperate, rainy climate (Tinley, 1977) although the seasonal pattern is similar.

Rainfall is a key factor determining the ecology of the GNP floodplain. Tinley's 1977 rainfall data were drawn from meteorological records up to not later than 1972. They are summarised along a west-east transect in **Table 2** below.

Table 2 Mean annual rainfall (mm) across a west-east transect through Gorongosa National Park and its immediate surroundings

Gorongosa Mountain	Báruè Midlands	Rift Valley	Cheringoma Plateau
2 037	1 320	840	1 024

The highest rainfall for one year was 2 550 mm recorded on the southern (windward) slopes of the mountain in 1967 (Tinley, 1977).

[6] Referred to sometimes as the Urema Trough (e.g., Tinley, 1977).

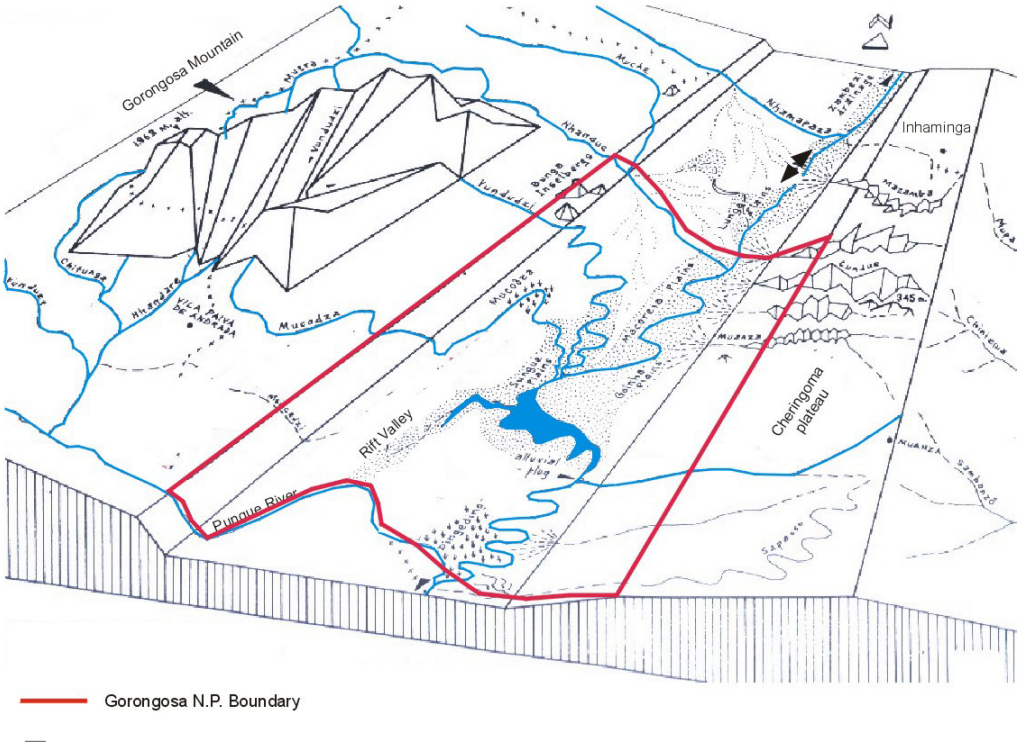


Figure 4 Main topographic and drainage features in relation to GNP

4.3.5 Hydrology

The timing of water flow into the floodplain, and its eventual departure are crucial to maintaining the Gorongosa floodplain in a condition that will support varied and abundant wildlife. An insufficient volume of water from the catchment or too rapid an out flow will result in a drier floodplain and subsequent changes in its habitats and fauna.

Many of the rivers in the Pungwe River basin flow into the GNP. The exceptions are tributaries that enter the Pungwe from the right (or south) bank, in the reach where the main river runs along the park's southern boundary. The largest component of the catchment is the Pungwe mainstream above the point where it abuts the southwest corner of GNP and its many tributaries further upstream, some of which extend back into Zimbabwe. However, this component of the total Pungwe River basin affects only the riparian habitat along the park's southern boundary and does not contribute water to the floodplain. During periods of high flood, it is possible that water may back up the Urema River and might temporarily inhibit outflow from Urema Lake, but it is not considered by this study to be a part of the Gorongosa ecosystem.

The floodplain's main sources of water are as follows:

- The Mucombeze River north of Urema Lake;
- Rivers draining the Cheringoma Plateau to the east of the floodplain;
- Rivers rising from Gorongosa Mountain and the Báruè Midlands to the west of the floodplain;
- The Nhandungue River, whose source is in the northwest sector of the Pungwe River basin.

All the rivers ultimately drain into Urema Lake, which in turn discharges through the Urema River into the Pungwe. The location of the Urema sub-catchment in relation to the Pungwe River basin is shown in **Figure 5** below.

*Figure 5 **L**ocation of the Urema sub-catchment in relation to the Pungwe River basin*

The above main rivers are shown on a larger scale in relation to GNP in **Figure 6** below. The sub-basins for each of the main rivers are described below.

MUCOMBEZE RIVER

The Mucombeze rises south of the very shallow divide separating the Pungwe catchment from that of the Zambezi[7]. It flows south-southwest along the Rift Valley into GNP, reaching Urema Lake in the southern half of the park. Its flow is seasonal. The water is highly transparent and pale green in colour ('clearwater').

Burlison *et al* (1977) cited in a report that, during floods, the Zambezi River could at times backup sufficiently to spill over the shallow divide, and drain down the Mucombeze into Urema Lake. This happened less often when flooding was reduced by closure of Kariba Dam[8] in 1958.

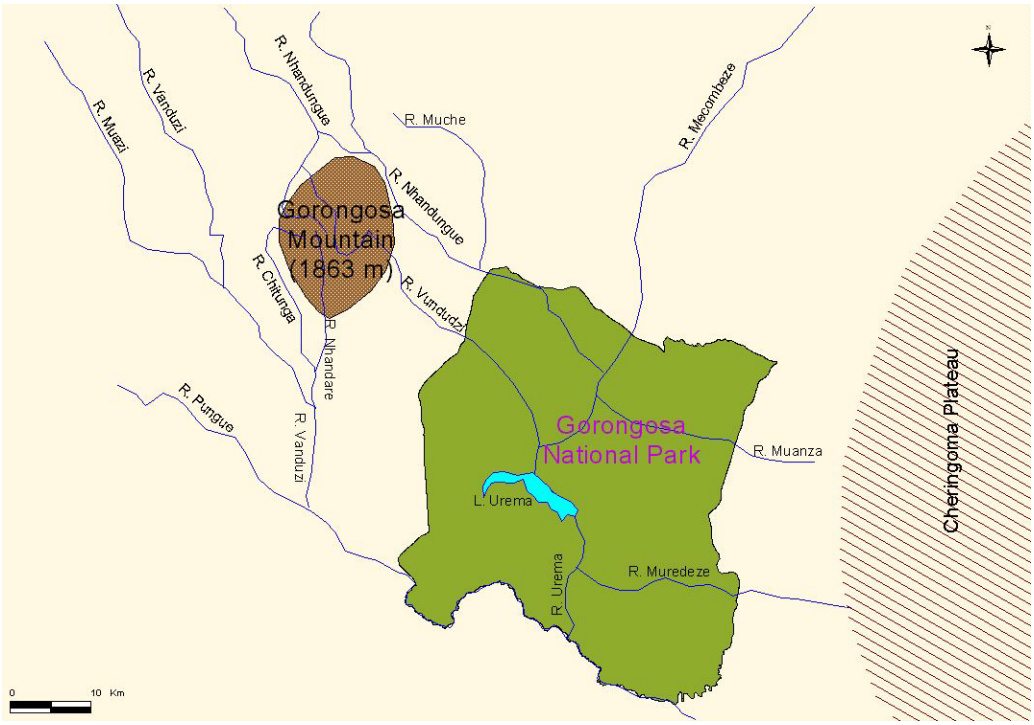


Figure 6 Main Rivers in Relation to GNP

RIVERS OF THE CHERINGOMA PLATEAU

Several seasonal rivers flow into the Rift Valley from the east. The principal ones are the Mazamba, Cundue, Muanza and Muaredzi. Their waters are relatively transparent and tea-coloured. All except for the last-named, they disappear below ground as they reach the valley floor.

[7] So shallow that Tinley (1977) postulates barbel and other fish travelling between the two catchments by way of small channels that form during rains.
[8] On the Zambezi River between Zambia and Zimbabwe.

The Muaredzi River is the only lateral tributary from the Cheringoma Plateau to cross the Rift Valley floor and discharge directly at right angles into the Urema, which it does below the lake. Tinley (1971) believed that the greater part of the floodplain grasslands and the lake owed their existence to this confluence. According to his theory, suspended alluvium deposited by the Muaredzi at its confluence with the Urema, formed a sand bank that acted as a plug, obstructing outflow from the very shallow lake and maintaining its level. Tinley (1977) rated this (along with the rivers bringing water from Gorongosa Mountain) an outstanding salient feature of the Gorongosa ecosystem. The plug, he believed, when present, determined the main critical height controlling drainage from the Rift Valley plains and was 'responsible for the partially endoreic nature of the Urema basin.' The plug was reinforced each year by fresh deposits. However, Tinley (1971) considered it was no longer completely effective because the narrow channel had become over-deepened by erosion and hippos so that floods were failing to inundate long enough to keep the invading savanna at bay. Burlison et al (1997) were unable to corroborate this theory but cited another opinion (Riney, 1977) that the plug had not worked 'recently'.

RIVERS OF GORONGOSA MOUNTAIN AND THE BÁRUÈ MIDLANDS

Five main rivers drain the Gorongosa mountain system as follows:

- The Chitunga and Nhandare drain the southern slopes, and after merging, discharging directly into the Vanduzi.

- The Vunduzi and Mocodza flow eastwards across the Midlands and into the Rift Valley and Urema Lake. They are the only two perennial streams, with flows declining considerably at the height of the dry seasons. The Vunduzi is the most important perennial river, because during the dry season, it maintains Urema Lake, upon which the previous high populations of GNP's hippopotamus (around 3 000-strong in 1970) and thousands of other wild ungulates depended.

- The Muera rises from the northwestern side of the mountain and flows northwards to join the Nhandungue. The latter runs southwest into the Rift Valley to join the Mucombeze as described below.

The Nhandungue River's catchment area of 3 700 km^2 is the largest of those flowing into the Gorongosa floodplain, and carries the largest quantity of sandy sediments during times of flood, originating from the northwest in Manica Province. It is a large, sandy river whose flow is dependent upon rainfall and is therefore seasonal over most of its length. However, between its confluence with the Muera and the point where it crosses the Rift Valley edge, surface flows occur throughout the year. Elsewhere, water lies not far below the sand, where it is available through digging by people and elephants.

At the Rift Valley edge, the Nhandungue is joined by another seasonal sandy river, the Muche. Further north is the Nhamapaza, which flows directly into the Mucombeze. The waters of all these rivers are classed as 'clearwaters'.

UREMA LAKE AND RIVER

Urema Lake varies considerably in size, from about 10 km^2 during dry seasons to some 120 km^2 during periods of maximum fflow (Tinley, 1977). The most important contributors to flooding are rivers that flow into the Rift Valley from the west, from the Gorongosa Mountain and the Báruè Midlands.

Although Urema Lake lies at about only 12 m above sea level, it is 100 km from the sea. The surrounding terrain is very flat, and large habitat changes may result from very small alterations in flooding and waterlogging. The floodplain ecosystem is therefore exceedingly sensitive to change—'natural' or man-made.

The only outflow from the Gorongosa ecosystem is through the Urema River, which drains Urema Lake, crossing the southern boundary of GNP to join the Pungwe River. The waters of the lake and Urema River downstream are turbid, yellow-ochre in colour and fairly opaque—so-called 'white waters'. This characteristic continues downstream below the confluence with the Pungwe.

OTHER WATER SOURCES

There are two thermal springs in the Gorongosa system as follows:

- A direct tributary stream of the Pungwe River rises immediately west of the southwestern boundary of the GNP, below the Bué Maria ridge, and passing over a point where heat is acquired from an underground source.

- One on the Rift Valley floor east of a rocky protrusion known as the Bunga Inselberg.

The system has the following two major aquifers:

- *Gorongosa Mountain:* This 600 km^2 massif, whose isolated relief triggers precipitation, and releasing water throughout the year, much of it entering the Gorongosa floodplain.

- *Cheringoma Plateau*: At the crest of the plateau, a sandy mantle overlying impervious clays absorbs and releases rain water east and west—the latter towards the Rift Valley. Perennial surface water occurs along the streams but disappears below ground on reaching the sandy beds and alluvial fans of the valley floor.

There are numerous seasonal pans. Tinley (1977) recorded 200 per km^2 on the Rift Valley floor, each 20 m or more in diameter. They formed an integral part of the geomorphic dynamics of termite hills, which themselves occurred at a density of 300 to the km^2. Pans depend upon rain and are unreliable as sources of surface water beyond July because most dry out before then. When dry, they seem more arid than their surroundings probably due to their high salinity. Tinley (1977) noted, however, that 'They are responsible for multiplying the diversity and abundance of resources in the savannah ecosystem.' The presence of pans, even for relatively short periods, encourages wild herbivores to expand their distribution so that they can use more extensive portions of the range before being forced back closer to permanent water as the year progresses.

Little data exist on river flows in the Gorongosa region. The only sources available to this study were Tinley's (1977) figures gathered over a short period during the height of the 1971 dry season (in October), and regular monthly measurements from one recording station taken only between 1956 and 1979.

The October 1971 measurements were taken from two rivers discharging into the Rift Valley from the west, the Vunduzi and Mucodza. The former was, at that time, the only perennial surface flow contributing to Urema Lake. Its rate of flow was 0.6 m^3/sec, with outflow from the lake measured at 0.2 m^3/sec. Flow in the Mucodza River was 0.02 m^3/sec. This was delivered to its mid-course marshy delta so that none reached the Urema Lake.

Table 3 gives a summary of the only other available water flow data related to the Gorongosa ecosystem. The flows were measured on the Urema River downstream of the lake over a 23-year period. Note that some entries have been tagged 'estimates only'. The low flow period is from July to November, rising in December with the onset of rains. Flows peak during the period February to April and declining in May and June.

Table 3 Mean monthly flow rates (m^3/sec) in Urema River near the southern boundary of Gorongosa National Park 1950-1973

	Station E81-85		Urema River 1950-1975										
	Data availability				Complete years 22				Incomplete years 1				
	Location		Elevation 12 m. On Urema River at southern boundary of GNP.										
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Average	2.61	4.28	11.81	33.27	50.80	56.42	47.00	26.16	8.99	4.94	3.34	2.78	**Monthly average**
Max	36.46	52.18	67.89	93.73	162.35	312.17	359.18	193.52	27.86	17.27	12.20	20.75	**20.87**
Min	0	0.21	0.25	1.06	3.74	3.74	3.74	3.19	2.21	1.33	0.76	0.27	

Comparison with rainfall data reveals a time lag of one to two months between peak precipitation in the Urema Basin and stream flow in the lower Urema. Seven of the meteorological stations recorded heaviest rains during November to March with peak months being December or January. Only the station at Chitengo (nearest to the run-off recording point) recorded a February peak.

Variations in flow between years are very erratic, especially during times of highest and least flow. The most striking were in for April (average 47 m^3/sec) with a maximum of 359 m^3/sec in 1976 and a minimum of 3.74 m^3/sec in 1968, and for November (average 4.28 m^3/sec) a maximum of 52.18 m^3/sec and minimum of 0.21 m^3/sec.

4.3.6 Plant Communities of the GNP Floodplain

'The Rift Valley substrates support the greatest concentrations of wildlife remaining in Mozambique.' (Tinley, 1977). This section reviews in greater detail the flora of this richly productive part of GNP.

There is a stark difference in the appearance of GNP floodplain between wet and dry seasons. During the wet season, vast areas are flooded. Floating pastures and conspicuous flowering water lilies appear. There is a widespread, lush, verdant growth. Small aquatic animals appear in abundance—barbels, frogs and turtles. In contrast, during the dry season, there is an absence of surface water except in the rivers and lake. Grasses shrivel and turn brown. Grass fires sweep through, blackening the plain but making little apparent impact on the thickets and forest patches (Tinley, 1977).

The main communities that create this mosaic of plant cover have been identified and described by Tinley (1977). They are listed below:

- Floodplain grasslands
- Scrub savannah
- Tree savannah
- Scrub-thicket
- Thicket
- Forest
- Aquatic herb communities

Floodplain Grasslands

A mosaic of several grassland sub-communities occurs on the floodplain comprising short, medium and tall grasses. Dry season fires burn all except short lawn-grass communities of Setaria and Echinochloa on areas most susceptible to flooding (inundated every year) and waterlogging. Lawn-grasses are a principal part of the diet of short and medium grass grazers such as oribi and hartebeest. Taller grasses such as Echinochloa-Vossia communities are subjected to heavy grazing by wild ungulates.

Scrub Savannah

The largest areas of scrub savanna are pure stands of Acacia borleae in the north of the park, and Hyphaene benguelensis in the south. Tinley (1977) observed that the latter, a species which normally grows to around 20 m tall, was maintained in a scrub state by elephants. Having now gone through almost 20 years of severely curtailed elephant activity, many of these palms have resumed normal growth. Scrub savannas also occur on old gardens, where *Combretum fragrans*, *Lonchocarpus capassa* and *Piliostigma thonningii* are most common. There is a solitary stand *of Acacia nilotica* in the north.

Tree Savannah

The following six major tree savannah communities occur depending on edaphic factors and available moisture:

- Mixed savannah (species of Acacia, Albizia, Lonchocarpus, Piliostigma and Sclerocarpa)
- Marginal floodplain woodland (*Acacia albida, A xanthophlea*)
- Knobthorn savannah (*A nigrescens*)
- Sand savannah (Burkea africana, Terminalia sericea)
- Mopane savannah woodland (*Colophospermum mopane*)
- Palm savannah (Hyphaene benguellensis, Borassus aethiopica)

Scrub-thicket

Pure stands of *Antidesma venosum* occur on the banks of the Mocombezi River and on some old channels of the Pungwe.

Thicket

Four types of thicket are found on the GNP floodplain. These are riverine, alluvial fan, tree base and *termitaria*. They contain a preponderance of species

whose seeds are dispersed by animals—perching animals such as birds and primates, and animals that use dung middens such as civets.

Alluvial fan thicket occurs on the fans formed along the edges of the Urema trough, interspersed with riverine thicket. Tinley (1977) recorded 35 species of woody plant, with six dominants: *Ficus sycamorus, Diospryos mespiliformis, Mimusops fruticosa, Trichilia emetica, Ekebergia capensis* and *Khaya nyasica*.

Tree base thicket is common and vigorously invades wooded savannas. Tinley (1977) recorded 29 species of woody plants including *Capparis erythrocarpus, Ziziphus mucronata, Deinbollia xanthocarpa* and *Jasminium sp*.

Large clumps of thicket are associated with termitaria. Tinley (1977) listed 55 species. None were dominant but the most common were *Salvadora persica, Capparis erythrocarpus, Thilachium africanum, Trichilia capitata* and *Cleistochlamys kirkii*. See subsection 4.3.8 for further comments on *termitaria*.

Forest

Two types of forest occur on the GNP floodplain. These are riverine forest and dry forest on duplex sands.

A patch of riverine forest occurs on the north bank of the Nhandungue River. Canopy height is about 30 m. Among the larger trees, Tinley (1977) listed *Albizia glaberrima, Blighlia unijugata, Bombax rhodognaphalon, Cordyla africana, Diospyros mespiliformis, Ekebergia capensis, Ficus sycamorus, Khaya nyasica* (the most abundant), *Sterculia appendiculata, Syzygium guineense* and *Trichilia emetica*. Further patches occur on old courses of the Pungwe River east of Chitengo, which range from evergreen to deciduous depending on species dominance.

Dry forest occurs in several extensive patches. Species found in the canopy and as emergents include *Xylia torreana, Pterocarpus antunessii* and *Millettia mossambicensis*.

Aquatic Herb Communities

Aquatic herbs flourish briefly in abundance, when seasonal pans fill with rainwater. Others occur in areas subject to seasonal flood and ebb across the floodplain, and in the rivers, streams, oxbows and lake. A broad range of habitats are exploited by submerged aquatics, floating aquatics, rooted aquatics with flowering aerial parts and emergent aquatics.

Reed beds grow along some stream banks and perennial backwaters. Herb communities appear on mudflats left by receding floodwaters. Some provide a source of grazing for ungulates.

4.3.7 Floodplain-Dependent Wildlife in GNP

'The spectacularly rich wildlife of the Rift Valley is a consequence of the mosaic evolution of forest thicket and savannah abutted against a floodplain grassland ecosystem of high primary productivity on base saturated soils.' (Tinley, 1977). While the basic ecological context may have changed little since Tinley wrote these words, the 'spectacularly rich wildlife' has taken a beating due to circumstances arising from a long period of civil unrest and occupation of GNP by opposing militias.

This subsection summarises descriptions of the wildlife in GNP as it was in the early 1970s, and how it may be again if it can be reinstated, given time and appropriate skills. An account of the extent to which wild animal resources have been eroded is included below, as well as recent information on conditions since the reinstatement of government control over the park.

Forty-six mammals have been recorded in GNP. These are listed in **Appendix 2**). White rhino had disappeared around the 1940s, cheetah in about 1950, and roan and tsessebe between 1950 and 1970. Two attempts at reintroduction were subsequently made: white rhino in 1970 and cheetah in 1973. In both cases, six individuals were reintroduced. None has been seen in recent years.

A feature of wild animal abundance and distribution in the Gorongosa ecosystem was the extent to which it concentrated throughout the year upon the Rift Valley floor. Land east and west was only lightly stocked although water was available in the many streams for much of the year. Some large ungulates did move out of the Rift Valley seasonally into the hills—elephant, sable, hartebeest and eland although not necessarily in unison. For example, sable moved into the hills during the wet season, hartebeest did the reverse.

In terms of numbers and biomass of its large wild animals, the fauna of the GNP floodplain was dominated by eight grazing ungulates (buffalo, wildebeest, waterbuck, zebra, eland, sable, hartebeest and hippopotamus) and one mixed feeder (elephant). Grazers accounted for over 60 per cent of the total estimated floodplain biomass of large herbivores; mixed feeders perhaps 35 per cent. Obligate browsers accounted for very little biomass. They were mostly small in size (e.g., suni, oribi), and did not form herds or occupy habitat away from the floodplain (e.g., klipspringer, blue duiker). Tinley (1971) produced estimates of biomass in the principal large animals of GNP, based upon aerial counts, and concluded that the floodplain was supporting more than five tonnes per km^2. See **Table 4** below.

Table 4 Biomass of nine large ungulates on the floodplain of GNP, 1968

Animal	Number of animals	Mean body mass (kg)	Biomass (kg)	Percentage of biomass	Biomass kg/km^2
Elephant	2 200	3 182	7 000 400	34.6	1 750
Buffalo	14 000	500	7 000 000	34.6	1 750
Hippo	3 000	500	3 408 000	17.3	852
Wildebeest	5 500	182	1 001 000	4.9	250
Waterbuck	3 500	205	717 500	3.5	179
Zebra	3 000	216	648 000	3.2	162
Eland	500	455	227 500	1.1	57
Sable	700	159	111 300	0.5	28
Hartebeest	800	92	73 600	0.3	18
Total					**5 046**

(Source: Tinley, 1971)

There were several species of smaller ungulates and 12 carnivores including lion, leopard and spotted hyaena.

A seasonal movement of wildlife took place from the wet season floodplain grassland pastures to the dry season marshland, riverine and moist savanna grassland habitats. Two areas of year-round concentration were in the delta-like area where the Vunduzi and Mucodza join Urema Lake, and in the grasslands surrounding the lake to a radius of 5 km. Hippos used the latter throughout the year. Grasses were kept short through heavy grazing pressure but copious quantities of dung, which added fresh inputs of nitrogen and nutrient materials, kept them growing vigorously.

Floodplain grasslands were used in rotation. First, when mid-year drying out forced most ungulates except hippos to move towards the marshlands. the secondly, during inundation in January or February. The most used marshlands were at the southern end of the park at the Urema-Pungwe confluence, and at the Mucodza marsh to the west of the floodplain.

Elephant used the whole range of habitats but favoured riverine areas and areas of tall-grass *Acacia* savanna and riverine forest. Highest year-round densities were in three riverine zones; the Nhandungue, the western Vinduzi-Mucodza-Mupuaze area on the west side of the Rift Valley and in the Urema-Pungwe area.

In 1977, the government department then responsible (DINAP) expressed some disquiet over what it perceived to be ecological problems. These were related to the apparent drying out of the park, unplanned fires that were

damaging the habitat and some wild animals that were thought to be over-abundant and over-utilizing the range. These concerns were examined by Burlison *et al* (1977). Their conclusions were:

- Drying out did seem to be occurring. If it continued, the likely outcome would be changes to the habitat mosaic, favouring wooded areas over floodplain. This would lead to increases in bushbuck, greater kudu, nyala, eland, sable and hartebeest but declines in grazers such as zebra, wildebeest, waterbuck, oribi and hippo.

- Evidence concerning fire was inconclusive.

- No evidence was found to support overpopulation. Some species showed signs of stress but not excessive, and the year had been a very dry one. They did not recommend any culling[9].

Apart from the concerns identified above, prior to the long period of armed conflict and while GNP was under the control of a government department, the large wild animals appeared to have been healthy and abundant. When government conservation workers were able to re-enter the park in 1993, they found considerable damage to both wildlife and infrastructure.

Table 5 gives population estimates for the nine largest wild animals, which had been the subject of censuses since 1968. Subsequent population estimates for 1970 and 1979 suggested that there had been little overall change. There may have been variations from year to year, but estimates are not precise figures since they are arrived at through aerial survey and stratified statistical sampling techniques. Furthermore, confidence limits can sometimes be quite wide. Nevertheless, the three years of 1968, 1970 and 1979 suggest continuation of an abundant and healthy wildlife resource, which the work of Burlison *et al* (1977) did nothing to dispel.

When government control was reinstated in 1993, the first surveys discovered that a massive loss had been sustained, especially of the three largest animals (elephant, buffalo and hippo), which when butchered yield the biggest quantities of meat per carcass. Elephant had the additional value of ivory that could be traded.

Numbers for 2003 (based on verbal reports of a census the previous year[10]) suggest that populations are slowly increasing, especially for elephant and waterbuck especially. However, they are still far below those recorded during the 1960s and 1970s. When populations are smaller, confidence limits tend to be wider so that the estimates given above from 1993 onwards may be very

[9] Ironically, a massive, albeit unplanned and unmanaged, cull began five years later.

[10] Data from aerial surveys later than 1994 have not been released to the study. The figures given under 2003 are based upon verbal reports from the Warden.

imprecise. Where numbers are low and the animals widely scattered it may be less misleading simply to note 'present in small numbers'.

Table 5 Population estimates of nine large wild animals in Gorongosa National Park from 1968 to 2003 (P = present in small numbers)

Animal	Year					
	1968	**1970**	**1979**	**1993**	**1994**	**2003**
Elephant	2 200	1 900	3 000	4	108	250
Buffalo	14 000	11 900	18 000	0	0	25
Hippo	3 000	3 200	4 800	0	0	25
Wildebeest	5 500	4 900	1 900	7	0	P
Waterbuck	3 500	2 500	800	200	129	1 500
Zebra	3 000	-	-	7	65	30
Eland	500	-	-	0	0	P
Sable	7	-	-	700	12	P
Hartebeest	800	-	-	0	156	P

(Source: for 1968-1994 IMPACTO, 1998; 2003, verbal reports from Warden.)

The smaller animals seem either to have diminished less during the armed conflict or have recovered more rapidly. During drives through the park in early February 2003, waterbuck, bushbuck, impala, oribi, warthog and baboon were often seen, especially the first-named. Park personnel reported that several other animals not listed in **Tables 4** and **5** are alive and well *viz.,* wild dog, spotted hyaena, leopard, greater kudu, nyala, red and grey duikers and klipspringer. Lions have survived. In the absence of their usual former prey, wildebeest and zebra, they have taken to eating warthog. Recent signs of elephant were found at the Urema River crossing point in February 2003.

4.3.8 Other animals

Bird life was and is abundant and varied. About 200 species are known to occur. A selection is listed in **Appendix 3**.

The herpetology of the area has not been studied in detail but crocodiles occur in the lake and Urema River. Snakes, turtles, lizards and geckoes are abundant. A variety of fishes are found in the lake and rivers.

Termites and termitaria, although small in size are abundant in number. Termites have visible impacts upon landscapes and ecosystems, especially the hill-building species, which are numerous on the floodplain of the Gorongosa ecosystem (300 hills/km^2). Tinley (1977) recorded six genera. The

most common was *Macrotermes mossambicus,* one of three hill-builders. The others either build mounds up to 50 cm tall or construct nests on tree trunks.

The immediate visual impacts that hill-building termites have on the floodplain landscape is the numerous thicket islands or small bare hills while in their formative or invasive stage. In the formative stage, the hills become attractive to perching birds that defecate and deposit seeds locally. The seeds geminate and produce plants, which reinforce the attractiveness of the hill to animals. Termite hills pass through several stages as they develop, mature and finally erode away, at the end of which a pan may appear that gathers rainwater during the wet season. This process is aided by trampling animals and the process may be hastened where ungulates are abundant.

4.3.9 Human Influences

Extant Mozambican law does not permit people other than management staff to reside in a national park. Notwithstanding, most national parks in Mozambique have residents due to an uncontrollable influx that occurred during and after the armed conflict.

An estimated 10 000 to 15 000 people practicing shifting cultivation now live inside GNP, the majority on the floodplain. The people also hunt and fish illegally in the park. Another 20 000 or so live nearby and cultivate the slopes of Gorongosa Mountain and the land between it and the park. All these human activities affect the ecosystem. Those in the floodplain directly impact upon the mosaic of habitats and the associated wildlife. Those around the mountain interfere with the floodplain's chief source of water. The indications are that these populations will grow. A growth rate of between 2.5 and 3.0 per cent per year is a not unreasonable forecast.

This problem of human settlements requires early attention to safeguard the long-term future of the park.

4.3.10 Factors Affecting the Hydrology of GNP

The following factors have an influence on the hydrology of the GNP:

The Balance between Inflow and Outflow

The Gorongosa ecosystem and lands immediately adjoining it have a high potential for mass and low-density tourism. If reinstated to its previous levels, tourism can earn foreign exchange and lead to social and economic benefits for the local inhabitants. This potential presupposes a sustained abundance and variety of large wild animals, which once occupied the central floodplain. These may be re-established following a successful programme of rehabilitation and subsequent management.

The abundance and variety of wild animals is dependent upon the existence of a diverse mosaic of habitats on the floodplain, which include large expanses of grassland. This, in turn, depends upon a hydrological regime in which sufficient water is discharged into Urema Lake each year, and the outflow is sufficiently controlled to ensure that the water backs up, spreads across the floodplain and takes some three or four months to recede. It is the balance between water in and water out that maintains the floodplain in conditions that are optimal for wildlife diversity and abundance.

If the balance changes, so will the pattern of habitats. Reduction in extent or duration of floods could lead to bush encroachment at the expense of grasslands. Carrying capacities for different animals would be affected differently. Grazers such as hippo, zebra and wildebeests would tend to increase in wetter environments but decrease under drier conditions. The situation would be *vice versa* for browsers. In principle, it would be possible to manipulate a floodplain's hydrological regime to arrive at whatever might be the desired balance of species[11]. In practice, such manipulation will probably be extremely difficult because inflow is subject to the impacts of land use by humans that will not be simple to address.

The Inflow

Burlison *et al* (1977) considered that inflow depended upon three factors; rainfall, types of land use on the catchments (which affects the soils' capacity to retain water and the flow in streams and rivers), and volume of water spilling over from the Zambezi during floods. They discounted changes in rainfall, and the current study concurs, not least because rainfall data are insufficient to make any other judgment.

The most important part of the Urema catchment is Gorongosa Mountain. Rainfall is highest here and the massif acts as a giant aquifer. Past reports by Tinley (1977) and Burlison *et al* (1977) have recorded the spread of cultivation up the slopes of the mountain, the felling of trees, burning and the consequent destruction of natural plant cover. These circumstances continue to the present day, especially along the eastern and southern slopes, where cultivation is being practiced on slopes of up to 45º. These practices could have marked effects upon the local hydrological regime, leading to reduced water-retention in the soil, accelerated run-off after rain, and higher incidence of flash flooding. However, there are no hydrological data for the mountain or other Urema catchments, east or west. This makes it impossible to quantify the effects of land use on the supply of water to GNP. It can only be surmised that expansion of cultivation on the mountain and in the other catchments is likely to impact adversely upon the hydrology of the park.

[11] The decision as to what the desired balance may be is not a technical one although deciding the means of achieving it will be. It is what Bell (1983) called an 'aesthetic decision'.

Land use within GNP could also affect stream flow. Riney (1977) suggested that large-leafed, rapidly-growing secondary vegetation developing in abandoned gardens could be causing increased evapo-transpiration, lowering the water table and reducing seepage from soil to streams and reducing flow. Burlison *et al* (1977) considered that this might account for a reported flow reduction in the Vunduzi River, although that report was only anecdotal.

Burlison *et al* (1977) thought that a reduction in spill from the Zambezi during times of flood, caused by closure of Kariba Dam in 1958, had resulted in reduced water entering Urema Lake from the Mucombeze River. Their evidence arose from an examination of water levels recorded on the Zangue River, about 10 km from the Zambezi and outside the Pungwe River basin, which had dropped significantly after the dam was closed. If this is correct, the effect is probably permanent, because Kariba and the more recent Cabora Basa dam now regularise the flow of the Zambezi.

The Outflow

If the Urema Lake water discharges too quickly, floods will subside more rapidly. This will cause the floodplain to dry out earlier in the year, leading to changes in the distribution and diversity of plant communities, the associated wildlife abundance, species variety and distribution.

Tinley (1969, 1977) considered that the key to outflow was the plug formed by alluvial deposits at the confluence of Muaredzi with Urema. He believed that it had formerly maintained a higher water table. No one seems to have investigated this phenomenon further, although Riney (1977) also considered that the plug had not functioned in recent years.

4.3.11 Recommendations for Maintenance of Floodplain System

Records of Water Flow

Recording stations should be set up on selected steams flowing into the Urema trough from Gorongosa Mountain and Cheringoma Plateau and on the Mucombeze River. This will create hydrological data upon which to base future management decisions.

Gorongosa Mountain

In principle, Gorongosa Mountain should be maintained as an aquifer that continues to deliver water to the GNP floodplain in quantities no less than the present day and at rates and timing matching those of the early 1960s. Delivery should ideally be yearlong in some streams, but accepting that flow rates may drop to very low levels during late dry seasons. In practice, targets for flow rates cannot be set because there are no quantitative data for stream flows into the park currently or at any time in the past. But it should be

possible to set qualitative, rule-of-thumb plans that define the forms of land use that will be permitted, and the areas in which they can be practised on and around the mountain. There is reported to have been a 'ruling' that no cultivation was to be practiced above 700 m (DAI, undated) but observations show that this has been ignored.

Báruè Midlands and Cheringoma Plateau

Although not as pressing as Gorongosa Mountain and its environs, land uses on these parts of the catchment also need the application of rules and guidelines.

The Muaredzi Plug

Tinley (1977) thought it essential to maintain the plug at the confluence of the Muaredzi and Urema so as to ensure the continued survival of the floodplains and marshlands, which sustain the large wildlife biomass. It appears that the theory was not widely accepted, and was not corroborated by Burlison et al (1977).

The subject needs detailed examination to decide whether current outflow is sufficiently controlled by natural circumstances to maintain water levels in the floodplain. If not, recommendations are needed as to what remedial interventions may be practicable. They could include construction of a controllable barrage that would allow flooding to be manipulated. This would require a very accurate land survey to determine levels, and a careful evaluation of environmental consequences.

Human Populations

In as far as is possible people should be encouraged to leave the park, and all possible encouragement and assistance be given them to do so. It may however be a very long process. Coercion could be counter-productive but there may be incentives in the form of improved social services. Movement within the park should be considered, shifting people from core biodiversity areas to less sensitive ones. As an aid to internal movement, the park's management plan should identify, map and describe different management zones, each with its objectives and strategies for achieving them, including limitations on access.

4.4 Protected conservation areas (PCAs) in Zimbabwe

4.4.1 Nyanga National Park

Nyanga National Park (NNP) is located in the Eastern Highlands of Zimbabwe and currently covers an area of 330 km^2 with more than 50% of the Park occurring within the Pungwe catchment (**Figure 3**). The Park includes Mt.

Nyangani, the highest peak in Zimbabwe (2 592 m) and the Mtarazi Falls, the highest waterfall in the country (762 m).

Since it's creation NNP has been increased in size through several land acquisitions. As a result of the acquisition by the Zimbabwe Government in the past decade of various large tracts of unused and unusable properties that abutted onto Mt. Nyangani in the Nyanga district, and adding these onto the existing Rhodes Nyanga National Park, a very large percentage of each of the various ecosystems that occur in this general area is now protected. The last property to be acquired was Nyazengu, a private nature reserve at the western foot of Mt. Nyangani that had been nurtured and developed over many years by a private family from Harare. The Park now stretches all the way down to the upper boundaries of the tea estates, and much of it falls within the catchment of the Pungwe River.

The wetlands of the area support a variety of birds including African Black Duck, Thickbilled Weaver and Red Chested Fluffttail whilst the montane grasslands provide habitat for a variety of interesting bird species such as Blue Swallow, Grassbird, Broadtailed Warblen and Wailing Cisticola.

Large mammal species include klipspringer, kudu, sable, blue duiker (Zimbabwe's smallest antelope) and the Samango monkey. Tthe Eastern Highlands is only area where this species of monkey occurs in Zimbabwe.

The Nyanga region is one of Zimbabwe premier holiday destinations and offers a wide range of accommodation facilities for anglers, birdwatchers and hikers including quality hotels, bed and breakfast, self catering facilities as well as camping sites in the National Park.

However, all is not yet well insofar as conserving this area is concerned. There is still a group of families who live in the forest area above the western (top) boundary of the Eastern Highlands Estate and who have progressively been opening up the forest there for cultivation over a long period. Also, the Mutasa Rural District Council's 1:50 000 map showed that six kraals are resident in the Mtarazi section of the park. A further cause of great concern is that a local chief is alleged to have been selling off rights for people to settle in the forest area in what has hitherto been the Gleneagles Nature Reserve adjacent to Aberfoyle Tea Estate. These new settlers have apparently already felled a substantial portion of the forest that until now has been the focal point for bird-watchers to be taken on guided tours.

4.4.2 Other Protected Conservation Areas in Zimbabwe

Other PCAs within the catchment are the Ringing Rocks Botanical Reserve on Chingamwe Forestry Estate (Wattle Co), and the various unplanted areas on the tea estates. The Ringing Rock reserve is a narrow strip of about one hundred hectares, stretching along the rim of the Honde Valley escarpment on

the south side of the Mtarazi Falls section of the National Park. It comprises short open grassland with many wildflowers and is located on the dolerite sill that caps the escarpment, with a small outlier of the rare *Protea asymmetrica* as one of its principal attractions.

All the tea estates have protected their patches of evergreen forest as well as the strips of riverine vegetation along their stream banks.

Stream bank vegetation in Zimbabwe is protected by law. Unfortunately, in the past decade in the Communal Farming Areas there has been a complete breakdown and a disregard for the laws that protect stream banks under the Natural Resources Act. Prior to Independence in 1980, the Streambank Regulations were rigidly enforced and every kraalhead and Headman was fully aware of what had to be conserved. In the case of all the major rivers (Pungwe, Honde, Nyamingura, etc) these were named and listed and the full 100 foot (30 m) zone on each bank was to be left intact. On the smaller rivers (all of which were also named), the protected area was reduced to 60 feet (20 m) on either bank. All other watercourses were required to have a 30 foot (10 m) strip left uncultivated down the center to act as a waterway in case of severe storms.

In the Holdenby Communal Area, most of the riverine forests have been felled in the past decade and maize is being grown right down to the water's edge. There is currently no attempt being made to rectify this situation.

4.4.3 Recommendations

It is highly desirable that at least one representative sample of adequate size of each of the different ecosystems that occurs in the basin is kept as a permanent sample of that ecosystem and of the biota that it supports. This will require that sites need to be identified where such reserves can be established if these lie outside of the National Park. Education of the persons who reside nearby will be necessary to help ensure that they understand the necessity of preserving such samples, and that they help to protect them.

5 WILDLIFE

5.1 General

This section addresses fauna occurring outside of Protected Conservation Areas (PCAs). Wildlife occurring in PCAs is described in the preceding section. Current knowledge of the fauna of Mozambique (with the exception of large mammals) is poor and this is particularly true for the Pungwe/Buzi floodplains. The low levels of species diversity and endemism may, therefore, at least partly be due to the lack data.

5.2 Mammals

Large mammals are mainly restricted to Protected Conservation Areas. These are described in the previous sections.

Wetland dependent mammals include the African clawless otter (*Aonyx capensis)*, which is found along all waterways that provide adequate cover for concealment and shelter for breeding. The spot-necked otter (*Lutra maculicollis)* is also known to occur in wetlands of the Pungwe River basin.

5.3 Avifauna

5.3.1 Wetland Avifauna of Pungwe/Buzi Floodplain

The most important area for birds outside the PCAs is the lower Pungwe floodplains. The Buzi and Pungwe rivers flood around 4 500 km^2 of wetlands in their deltas (Hughes and Hughes 1992).

The Pungwe/Buzi floodplain supports several bird species with threatened global concern status including the Wattled Cranes (*Bugeranus carunculatus*), Woolynecked Stork (*Ciconia episcopus*), Saddlebilled stork (*Ephipiorhynchus senegalensis* and Caspian tern (*Sterna caspia*).

Of special interest is the Wattled Crane, a globally endangered resident of sub-Saharan Africa. The vast majority of the population (more than 95% of an estimated global population of 15 000 birds) occurs in south-central Africa, in the floodplains and dambos of the Zambezi, Pungwe, lower Zaire, and Okavango River basins. Within the region, Wattled cranes are believed to migrate between the lower Pungwe floodplains and the GNP (the Gorongosa “tandos”) as well as the Zambezi Delta floodplains. In undisturbed floodplain systems, the breeding cycle of Wattled Cranes is intimately linked to the natural flood cycles of rivers. Wattled Crane pairs are “triggered” to nest as floodwaters begin receding after peak flooding. Nesting in deep open water after the major flood rise and crest ensures that nests will be protected from predators and wildfires, but will not be drowned by further rising floodwaters. As floodwaters slowly recede, Wattled Cranes raise their single chick on the pulse of exposed plant and insect life.

The branches of mangroves trees act as roost sites for feeding Egrets, Cormorants, Storks and Herons along river channels, where they hunt on fish and other marine animals. Mangroves are also very important as perch for feeding African Fish Eagles.

A list of some of the bird species recorded in the Pungwe/Buzi floodplain is given in **Table 6** below.

Table 6 Bird species recorded in the Pungwe/Buzi floodplain

English Name	Scientific Name
Greyheaded Gull	*Larus cirrocephalus*
Caspian Tern	*Hydroprogne caspia*
Little Egret	*Egretta garzetta*
Cattle Egret	*Bubulcus ibis*
Yellowbilled Egret	*Egretta intermedia*
Great White Egret	*Egretta alba*
Reed Cormorant	*Phalacrocorax africanus*
Grey Heron	*Ardea cineria*
Saddlebilled Stork	*Ephippiorhynchus senegalensis*
Yellowbilled Stork	*Mycteria ibis*
Woollynecked Stork	*Ciconia episcopus*
Wattled Crane	*Grus carunculata*
African Fish Eagle	*Haliaetus vocier*
Blackbreasted Snake Eagle	*Circaetus gallicus*
Whimbrel	*Numenius phaeopus*
Whitefronted Plover	*Charadrius marginatus*
African Jacana	*Actophilornis africanus*
Redeyed Dove	*Streptopelia semitorquata*
Giant Kingfisher	*Ceryle maxima*
Malachite Kingfisher	*Alcedo cristata*
Mangrove Kingfisher	*Halcyon senegaloides*

5.3.2 Restricted Range Species

A separate subspecies of the Whitebreasted Alethe (*Alethe fuelleborni*) has been recorded for Gorongosa Mountain and lowland forests near Dondo. The species is partly migratory breeding in montane forest and moving to the foothills and coastal forest in the cold season. The birds recorded at Dondo are probably breeding on Gorongosa Mountain. The species must be considered rare and very susceptible to habitat destruction. The Greenheaded

Oriole (*Oriolus chorocephalus*) is recorded only for Gorongosa Mountain. This is considered an isolated sub-species characterised by a white wing patch *(O. c. speculifer).*

In Zimbabwe, 338 species of birds that have been recorded in the valley floor habitats in the vicinity of the Aberfoyle Tea Estate Club. In addition, a further nine species are known from the plateau and montane areas of the Nyanga National Park, bringing the total for the Zimbabwean portion of the Pungwe River basin to 347, a very impressive number.

Some of the rare and restricted range species recorded in the Zimbabwean portion of the Pungwe River basin include the Southern Banded Snake Eagle (*Circaetus fasciolatus;* lowland forest), Palm-nut Vulture (*Gypohierax angolensis;* lowland forest), Red-breasted Sparrowhawk (*Accipiter rufiventris*; montane forest), Taita Falcon (*Falco fasciinucha;* montane cliffs), Blue Swallow (*Hirundo atrocaerulea;* sub-montane grassland), Swynnerton's Robin (*Swynnertonia swynnertoni*; Montane forest), Chirinda Apalis (*Apalis chirindensis*; montane forest), Red-chested Flufftail (*Sarothrura rufa*; High and low marshlands), Striped Flufftail (*Sarothrura affinis*; Montane wetlands and damp grass), Buff-spotted Flufftail (*Sarothrura elegans;* Lowland & submontane forest), African Finfoot (*Podica senegalensis*; Lowland rivers) and Marsh Tchagra (*Tchagra minuta*; lower grassland and vleis). The Wattled Crane (*Bugeranus carunculatus)* has been recorded in high altitude wetlands but has not been observed for several years.

5.4 Reptiles

The Nile crocodile (*Crocodylus niloticus),* monitor lizard (*Varanus niloticus)* and python (*Python sebae*) are amongst the more common larger reptiles of in the Pungwe River basin.

The only strictly endemic vertebrate in the Pungwe River basin is the Pungwe worm snake (*Leptotyphlops Pungwensis*), which has been recorded for the lower Pungwe floodplains. Three other snakes that are nearly endemic to the Zambezi Delta floodplain and may occur in the Pungwe/Buzi floodplain *viz.,* floodplain water snake (*Lycodonomorphus obscuriventris),* dwarf wolf snake (*Lycophidion nanus)* and eyebrow viper (*Proatheris superciliaris)*. There is general consensus is that the Zambezi Delta is relatively new and that there has therefore been insufficient time for distinctive biota to evolve compared to the wetlands and deltas of the Pungwe and Buzi Rivers. It is probable that restricted species and distinct biota may be found in the Pungwe/Buzi floodplains.

6 TOURISM

6.1 Background

Tourism in Zimbabwe is much more developed compared to Mozambique. This situation is due to the long period of armed conflict (1979-1992) in Mozambique during which there was an almost total absence of tourism.

Within the Pungwe River basin the two main conservation areas that attracted significant numbers of tourists are the Gorongosa National Park in Mozambique and Nyanga National Park in Zimbabwe. The armed conflict in Mozambique precluded any management within GNP. Wildlife populations were decimated and infrastructure destroyed. Consequently, tourism based on non-consumptive use of wildlife and landscape in the Zimbabwean portion of the Pungwe River basin, thrived while in Mozambique this type of tourism was non-existent until about 2002. In recent years the number of tourists visiting the Nyanga area has declined due to the economic and political situation in Zimbabwe, whilst in Mozambique a small number of tourists have started to visit GNP.

Before Mozambican independence in 1975 the Savannah area, north of Beira (and Beira itself) attracted large numbers of tourists from Zimbabwe (then Rhodesia) seeking a “coastal experience”. Since the mid 1990’s, tourist infrastructure and facilities have gradually improved in the Beira coastal area. The number of tourists visiting the area has increased in recent years although by national and regional standard, numbers are not high. Within the Mozambican portion of the Pungwe River basin the Beira area is by far the most developed with regard to tourism (the Ministry of Tourism has 757 registered beds for the Beira area out of a total of 806 beds for Sofala Province as a whole).

6.2 Tourism in Mozambique

6.2.1 Number of Officially Registered Tourist Beds

The number of tourist beds registered with the Ministry of Tourism for Manica and Sofala Province per district is given in **Table 7** below. The location of these districts in relation to the Pungwe River basin is shown in **Figure 7**. The Beira area has by far the highest number of officially registered tourist beds (757), followed by the town of Chimoio (314 beds) located on the perimeter of the Pungwe River basin.

Table 7 Registered Tourist Beds in Manica and Sofala Provinces

Province	Town/District	Number of beds
Sofala	Beira	757
	Marromeu	23
	Dondo	6
	Gorongosa	20
Manica	Chimoio	314
	Manica Town	80
	Gondola	28
	Guro	20
	Barué	11
	Messica	18
	Garuzo	20
Total		**1 297**

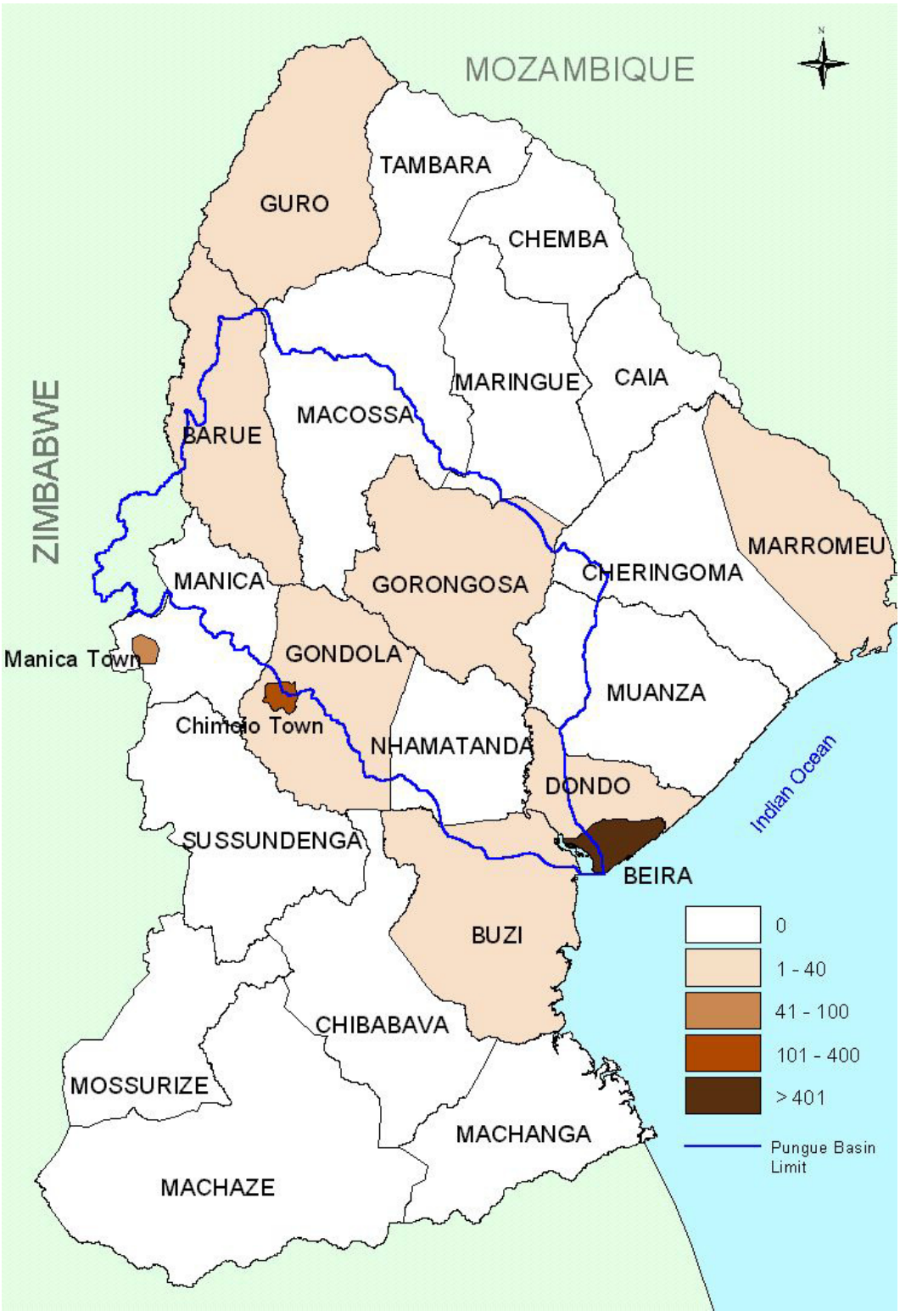


Figure 7 Tourist Beds per District/Town

6.2.2 Tourism in GNP and Surrounding PCAs

The main objective of the Project is to increase the derived social and economic benefits for the people living in the basin. A widely held perception is that PCA and wildlife programmes are more concerned with the welfare of animals than of people. This is a fundamental misapprehension. PCAs are a form of land use that aims to produce human benefits as much as agricultural programmes do. However, when in the past, revenues earned from tourism and safari hunting have bypassed local people and accrued directly to central government or to private investors, the misapprehension was understandable. This report stresses that effective management of GNP and other PCAs in the Pungwe River basin can lead to social and economic benefits for local communities. This opportunity would be lost if GNP's wildlife potential were allowed to decline through ignorance or neglect.

Thirty years ago, a regular flow of visitors came to GNP from South Africa and Rhodesia. In 1970, there were 14 750 and the following year about 20 000 (COBA & PROFABRIL, undated). Tourism collapsed due to a period of instability following independence in 1975 and, after that, the war. Since the park reopened in 1995, a trickle of visitors has appeared, mostly from Zimbabwe and South Africa, at the rate of up to 20 a month but usually much fewer.

Access to the park is along the newly reconstructed EN1 road north of the junction with the EN6 at Inchope. From the turnoff to the park headquarters, access is along a good gravel road. Tracks within the park are negotiable by four-wheel-drive vehicles.

The tourism season runs from April to December. The only accommodation currently available is a simple campsite near the park headquarters at Chitengo, which takes up to 40 tents. Water is available but is not potable. Plans are currently under discussion to relocate park headquarters on higher ground west of Chitengo, and to build a lodge on the prominence overlooking the Pungwe River at Bué Maria.

Adjacent controlled hunting areas have long supported safari hunts. Mozambique was internationally renowned for its high quality hunting safaris. In 1971, six outfitters were in business bringing in 201 hunter-clients, mostly from the USA, Spain and France (COBA & PROFABRIL, undated). In that year, 1 896 trophy quality animals were shot, which earned substantial foreign exchange. Meat from the carcasses was distributed to local inhabitants. Safari hunts ceased during the war and its aftermath, but outfitters are now back in business.

GNP has potential for a lucrative sustainable tourism industry, provided that the resource base is rehabilitated successfully and maintained that way. It will also require additional infrastructure and capacity building in management.

The resource base is the large wild animals in their natural environment. Studies in Zimbabwe and elsewhere have shown that most visitors to African national parks seek three wildlife experiences.

- To see particular species, of which the most popular are lion, leopard, cheetah and elephant.

- To see as wide a range of species in one location during the course of a visit, which may last one to three days.

- To see animals of any species in abundance, which in practice means animals that form large herds such as buffalo, wildebeest and zebra.

A minority of visitors may be seeking for more esoteric experiences such as bird or primate watching or seeking out species of any taxa that may be rare or endemic.

Safari hunters seek the traditional 'big five'—elephant, buffalo, lion, leopard and rhino—although black rhino is unlikely to be back on licence in the foreseeable future. They also look for a wide range of others species, and seasoned hunters may be hopeful of finding one that they have not successfully hunted before.

All these experiences were once, and can again, be enjoyed by visitors to GNP and hunters in the associated coutada, provided the resource base is rehabilitated.

6.3 Tourism in the Pungwe River basin in Zimbabwe

The Pungwe, Honde, and Nyamkwarara river valleys, together with their surrounding mountains and plateaus, form some of the most spectacular, varied, and interesting scenery in the whole of Southern Africa. The combination of their aesthetic qualities, the numbers of their rare and endemic fauna and flora, and the many relics of early indigenous occupations by long-vanished peoples, all render this part of Zimbabwe's Eastern Highlands to be a prime candidate for World Heritage status. The data on these factors that has been gathered for the purpose of recording the resources of the Pungwe catchment and the planning for the sound development of these, will be invaluable for assisting to have this area designated as a World Heritage site.

The Nyanga area has been a prime holiday destination for much of the past century. Initially this for early white citizens to partake in the bracing and healthy climate and to recuperate from the rigours of life in the lower and hotter parts of the country. The lack of malaria and bilharzia was a further attraction for taking rest breaks there. A special hostel for school children from the hot Lowveld was established in the Nyanga village, and the Rhodesian Holiday Association built a budget-price facility for its less-affluent members.

To cater for the accommodation needs of an ever-increasing stream of local and international visitors, more and more hotels were built, and chalet accommodation was developed in the Rhodes Nyanga National Park and elsewhere. Holiday and retirement homes and cottages sprang up all over the high open Nyanga Downs. There are now two major hotels (Troutbeck and Montclair) and several smaller ones (the Rhodes Inyanga Hotel, the Pinetree Inn, Inn on the Ruparara and the Village Inn), but two have had to close due to the current lack of tourists (Brondesbury Park and the Angler's Rest). All of these are located in the vicinity of Nyanga village and nearby Juliasdale, just outside the periphery of the Pungwe catchment, but they serve the entire area. Within the actual Pungwe River basin inside Zimbabwe, smaller numbers of visitors can be accommodated at the Red Dragon Lodge near Hauna township, and at the clubs on the Aberfoyle, Eastern Highlands and Katiyo Tea Estates[12].

The attractions of the Nyanga area are manifold: the following are some of them (but not listed in any particular order):

- The Mtarazi Falls, second highest in Africa
- The Pungwe Falls
- The Inyangombe Falls
- The Honde Valley views
- The Pungwe Gorge view point
- The World's View scenic view over the western side of the Nyanga plateau
- The similar view from the Rukotso radio mast
- The many wildflowers in the high grasslands in spring, and the terrestrial montane orchids in late summer
- The hillsides clothed in mauve and purple heather at Easter
- The ferns in the montane forests
- The groves of flat-topped *Acacia abyssinica* next to bald granite domes

[12] Note: At the time of writing the number of guest beds and occupancy rates for the Zimbabwean portion of the Pungue were not available. It is therefore not possible to estimate water demand by the tourism industry in Zimbabwe as was done for the Mozambican portion (see Sections and 5.2.1 above and 5.4 below). Data related to the tourism industry in Zimbabwe are currently being obtained and this issue will be covered in follow up reports.

- The clear fast-running mountain trout streams set in grassy valleys
- The trout hatchery in the Nyanga National Park
- The spectacular upright granite pinnacles (Mahemasemike) near the Honde River, that are steeped in legends
- The view of the 1 500 m forested east face of Mt Nyangani from the tea estates
- The lush green manicured fields of tea that clothe the base of Mt Nyangani
- The dramatic view into the Nyamkwarara Valley on Stapleford Forestry Estate
- The razor-edged granite inselberg named Gorongo (or Gurunguwe) on the Mozambique border in the Nyamkwarara Valley
- The Ringing Rock (a natural rock gong) in the Botanical Reserve on Wattle Co's. Chingamwe Estate near the Mtarazi Falls.
- The numerous sunken stone-lined circular livestock pits and associated terraces on the Nyanga Highlands, built by long-departed people
- The thousands of hectares of ancient hillside terracing in Nyanga North, and the Ziwa field museum that displays artifacts from that era
- Prehistoric rock art (Bushman/San) in rock shelters in granite hills
- Modern foot-bridges made from lianes and vines over the Pungwe River
- The original stone-built stables and outbuildings, and the small museum of relics, that had belonged to Cecil John Rhodes who had bought and developed this estate, and who later gave it to the nation as a national park
- The birds and butterflies in the vicinity of the remaining sub-tropical forest vegetation

All the foregoing provide visitors with a wide range of potential activities:

- Hiking
- Mountain climbing
- Rock climbing

- Camping and caravanning
- Horse riding
- Trout fishing
- Bird watching
- Game viewing
- Photography
- Boating on the large dams
- White-water rafting on the Pungwe River during times of high flows
- Visits to tea factories to see how tea is made
- Golfing on the course set round a large lake at the Troutbeck Hotel
- The casino and golf course at the Montclair hotel

South African statistics show that they currently receive about 500 000 tourists per year, and that tourism there is developing faster than anywhere else in the world. Unfortunately, the recent problems in Zimbabwe have resulted in a very sharp fall-off of tourists to this country. In due course, once the present adverse situation in Zimbabwe is resolved, this country should be able to have a substantial share of those tourists by arranging for the attractions of the two countries to be packaged as a single entity.

6.4 Water demand by the tourism industry

The number of registered hotel beds for districts within and adjacent to the Mozambican portion of the Pungwe River basin is given in **Table 7** above. No data is available for Zimbabwe. However, it is expected to be higher than for Mozambique due to the relatively well-developed tourism facilities in the Nyanga area.

In Mozambique, Beira City has by far the highest number of guest beds (757 beds) followed by Chimoio town (314 beds). There are relatively few guest beds in the other districts and towns (varying between 6 and 80 beds). In total there are 1 297 registered guest beds in the Pungwe River basin area in Mozambique. Compared to other tourist destinations, the number of guest beds in the basin is low, e.g., there are more than 4 000 registered guest beds in Maputo-Matola.

Water use in the tourism industry varies between 400 and 900 litres per guest night (0.4 and 0.9 m^3 respectively) - see **Table 8**. Use of water in the guests' rooms accounts for largest quantities of water used in a tourism facility (33%) followed by kitchen use (18%) - see **Figure 8**.

Table 8 Water efficiency benchmarks (International Hotels Environmental Initiative)

No. of Rooms	**Water Use Rating (litres per guest night)**			
	Good	Fair	Poor	Very Poor
<50 Rooms	< 439	439 – 507	507 – 583	> 583
50-150 Rooms	< 583	583 – 674	674 – 806	> 806
>150 Rooms	<666	666 – 855	855 – 942	> 942

Assuming an average value of 500 litres per guest night[13], water consumption by tourists would be 378.5 m^3 per night for Beira city and 648.5 m^3 per night for the rest of the basin in Mozambique assuming 100% occupancy. The actual amount of water consumed daily by the tourism industry is likely to be much lower since occupancy is probably less than 50% on average. The Beira City Water Treatment Plant has an installed production capacity of 30 000 m^3 per day although it is currently producing 25 000 m^3 per day due to system losses. Water consumption by the tourism industry in Beira therefore accounts for less than 1% of the water supplied to the city.

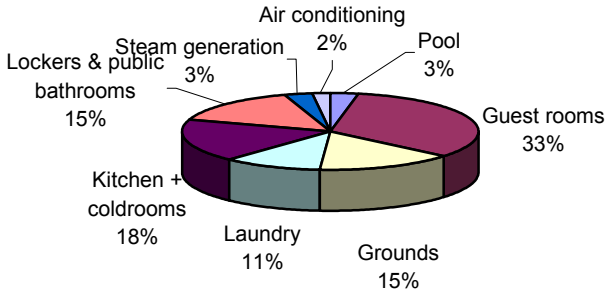


Figure 8 Distribution of Water Use in a Hotel

[13] This is probably an over-estimate as most hotels in Beira do not have swimimng pools or extensive grounds.

A large increase in the number of guest beds in the basin in Mozambique is not expected in the near future, as Beira is not a prime destination spot compared to other areas along the Mozambican coast[14]. The Ministry of Tourism is attempting to attract investment for wildlife-based tourism in areas adjacent to and within GNP. However, as wildlife populations are depleted, it is unlikely that GNP will be a major tourism destination in the near future. Even when wildlife populations recover, the tourism developments associated with the National Park are likely to be relatively small-scale.

[14] The tourism industry in Mozambique is largely based on the coastal 'experience'.

7 ENVIRONMENTAL IMPACTS ON CONSERVATION AREAS

7.1 Potential impacts on conservation areas (CAs) arising from development projects

The Pungwe is one of the few major rivers in southern Africa that is currently unregulated. Its source is in the Nyanga National Park (NNP) in Zimbabawe. There are, therefore, no upstream interventions that could impact on RNNP *per se.*

In contrast the CAs in Mozambique are located several hundred kilometers downstream of the river's source (e.g., the lower Pungwe/Buzi floodplains[15]) or are dependent on water flow from major tributaries (e.g., Gorongosa National Park floodplains). With regard to the latter, interventions that seek to remove water from the Gorongosa ecosystem or restrict or reduce stream flow into the Urema basin could impact adversely on the GNP floodplain, and reduce its potential to provide socio-economic benefits through non-consumptive tourism and safari hunting in the adjacent PCAs.

There are two specific proposed interventions (SWECO *et al*, 2003) that impact directly upon water flow in the Pungwe River *viz.,* the Bué Maria Dam on the Pungwe River and a small dam on the Nhandare River, a tributary of the Pungwe. Neither is likely to significantly affect the GNP floodplains *per se*. However, the Bué Maria Dam is likely to affect the Pungwe riverine vegetation immediately downstream, which forms the southern boundary of GNP and, more importantly, the lower Pungwe/Buzi floodplains.

7.1.1 Proposed Bué Maria Dam

The proposed site is at the extreme southwest corner of GNP. It would retain a lake upstream of this point on the Pungwe River. The objectives are to provide water for local irrigation and to supplement the Beira water supply. Damming of the river to create the lake the lake would reduce the volume of water passing downstream.

The Pungwe River is not considered to be a component of the Gorongosa floodplain ecosystem. The impact on GNP would be slight and confined to the riparian strip downstream of the dam where the Pungwe defines the park's southern boundary. The dam would therefore reduce flow along the park's southern boundary.

More importantly, the construction of the Bué Maria Dam would reduce annual runoff and alter the seasonal flow with consequent potential negative environmental impacts on the lower Pungwe/Buzi floodplains and estuary. The impacts on the Zambezi Delta, a similar (but much larger) deltaic system, due to the impoundment of the Zambeze River at Kariba and Cahorra Bassa are

[15] The lower *Pungwe*/Buzi floodplains are not formally gazetted as a PCA; they are nevertheless worthy of conservation due their biological importance.

well documented. These include an increased drying of the floodplains, with a concomitant increase in woody vegetation, and the alteration in the seasonal flooding patterns with consequent impacts on the breeding cycle of the some aquatic birds species such as waterfowl and on prawn productivity.

7.1.2 Proposed Dam on the Nhandare River

The purpose of this proposed dam is to secure water supplies for the small town of Gorongosa. The Nhandare arises on the southern slopes of Gorongosa Mountain, and joins the Chitunga and Vindudzi Rivers before reaching the Pungwe upstream of the proposed Bué Maria Dam. The impact on GNP would be confined to the southern boundary. Its significance would, however, be much less than that of the Bué Maria Dam.

7.1.3 Non-specific Land Uses

The greatest impacts on the hydrology of the Pungwe River basin probably arise from incompatible land use practices. This is especially the case with regard to the floodplains of the GNP where the removal of natural vegetation within the Urema catchment (most notably the removal of moist forests on Gorogosa mountain for plantation agriculture) and the cultivation on the floodplains will undoubtedly effect the ecology of the GNP floodplains.

7.2 Environmental impact assessments

In Mozambique, EIAs are covered by the Framework Environmental Law (Law No. 20/97) and EIA Regulations (Decree No. 76/98). Chapter IV of the Environment Framework Law (1997) provides for the application of environmental impact assessments.

> *An Environmental Impact Assessment (EIA) is required for projects likely to cause significant environmental impacts. The issuing of an environmental license is contingent upon the EIA and is a necessary prerequisite for the issuance of any other required licenses.*

An Appendix in the Mozambican EIA Regulations lists the activities which may have significant impact on the environment and which require environmental impact. These include he following:

1. Hydraulic works such as dams, dikes, channels, and irrigation and drainage systems.

2. Urban water supply and sanitation systems, their treatment stations and effluent disposal systems.

3. Hydroelectric power stations of any capacity.

4. Plans, programmes and projects that may affect directly or indirectly, sensitive areas, such as:

    a) coral reefs;

    b) mangroves;

    c) natural forests;

    d) small islands;

    e) zones of potential erosion, including dunes along the coastline;

    f) conservation or protected zones or areas;

    g) wetlands;

    h) zones where the habitats and ecosystems are in danger of extinction;

    i) zones of outstanding landscape beauty;

    j) zones of archaeological, historical and cultural value that should be preserved;

    k) areas where plant or animal species threatened with extinction;

    l) ground waters used for public consumption;

    m) areas for the protection of spring and water sources.

In the CA context, the introduction of EIAs under the new Environment Framework Law provides a tool for dealing with potentially harmful influences, and ought to be employed wherever existing or proposed interventions (policies, laws, land use practices, development projects, etc.) appear to be prejudicial to a PCA. Rigorous application of the EIA would ensure that decisions are made at an appropriate level, and that the issues would be assessed in the light of scientific study and advice. It does not guarantee that resultant decisions will necessarily favour PCA interests but it ensures that they will be taken into consideration and form part of the decision making process.

In respect of CAs, the purpose of the EIA is straightforward. Laws that regulate management of CAs often fail to address the impacts of many human interventions, unless specific provisions are made to guard against such impacts. This is where the EIA has a role to play.

A national park or reserve may be managed in accordance with its management plan and existing laws, but is powerless to resist influences from outside, for example:

- the toxic effects of pollutants discharged into a river from a source outside but upstream of the PCA;
- construction of a dam, barrage or irrigation project that could flood or withhold water from the PCA;
- expansion of areas under cultivation or changes in land use practices;
- changes in national or provincial policies on land use policies.

One system for making EIAs (Anon., 1992) recognises three levels of assessment: initial screening, environmental scoping and the actual EIA.

Initial screening is the first and simplest stage. It addresses basic questions such as (in the context of a PCA):

- What is the nature of the intervention (policy, legislation, land use practice, development, etc.)?
- What may be the general affect on the PCA?
- What species may be affected?
- What kind of habitats may be affected?
- How serious may the impacts be?

Where impacts are found to be minimal there may be no need to proceed beyond this stage, and consequently, time and effort need not be spent on unnecessary further investigation.

Environmental scoping is the second stage, which addresses more searching questions. It predicts the main impacts on components of the PCA such as its landscapes, hydrology, habitats, wildlife species (variety, abundance, distribution), infrastructure, tourism potential and management capability. The scoping assesses the importance of the predicted impacts, and indicates key mitigating actions. Based on the scoping assessment, more thorough specialist studies can be identified for the detailed EIA.

The EIA is the most rigorous level of assessment. It predicts impacts in as much detail as is possible, including cost implications. It identifies specific mitigating actions, and presents options for action to decision-makers. An EIA is usually a team activity that employs several specialists.

In the context of PCAs, a two-level approach is probably sufficient: the initial screening and the EIA proper. If, after an initial screening, the predicted impacts are believed to be minimal, it may be decided that there is sufficient evidence on which to base a report and recommendations, and avoid further unnecessary investigations. If an initial screening indicates that impacts may be serious, a full EIA would then be carried out, in which the effects of the intervention is subjected to greater scrutiny. A suggested checklist (taken from Clarke, 1996) for use at both levels is given in **Appendix 4**.

8 CONCLUSIONS AND RECOMMENDATIONS

1. Formally gazetted Conservation Areas occupy a significant portion of the Pungwe River basin (approximately 40%). Gorongosa National Park in Mozambique occurs wholly within the basin, and covers an area of 5 370 km^2 (17.2% of the whole basin). Nyanga National Park (330 km^2) in Zimbabwe occupies 1.1% of the basin. The other CAs (all within Mozambique) are classified as Controlled Hunting Areas (Coutadas).

Large mammal populations within the basin are largely restricted to gazetted conservation areas although (in Mozambique) these were substantially decimated during the long period of civil unrest (1979-1992).

2. Two extensive wetland areas providing suitable habitat for a variety of faunal species occur within the basin *viz.:*

- The Urema (Rift Valley) floodplains within GNP, which are dependent on water runoff from adjacent higher areas.

- The Buzi/Pungwe delta floodplains that provide habitats for a large variety aquatic bird species some of which are globally threatened.

4. Tourism in the Zimbabwean portion of basin is more developed compared to Mozambique. In Mozambique, the largest number of registered guest beds are in Beira City although water consumption by tourists is estimated to be less than 1% of the overall water supply to the city.

5. Wildlife based tourism in Mozambique is unlikely to attract large numbers of tourists in the near future due to depleted wildlife populations in the CAs. Safari hunting will continue to attract a few high-paying tourists; demand for water related to this type of tourism is very low.

6. Large development projects on the Pungwe River such as the proposed Bué Maria Dam are likely to have significant negative environmental impacts on the ecology of the Buzi/Pungwe delta floodplains due to reduced flow accompanied by changes to the seasonal flow. Projects of this nature will require environmental screening followed by an EIA in accordance with national legislation. Similar development projects in the Urema sub-catchment that affect the release of water to the GNP floodplains will also require an EIA prior to project implementation.

7. It is recommended that an environmental unit be established within ARA-Sul and ZIMWA. The unit need not necessarily be large and may initially involve the nomination of a focal point person. Training and capacity building will be required for the “unit”, this could include:

- National environmental legislation/EIA regulations.

- EIA procedures.

- Use of the screening form/checklist to identify impacts on conservation areas (see **Appendix 4**) of this report).

- Donor agencies environmental safeguard policies for approval/financing of projects.

- Inclusion of environmental safeguards into tender and contract documents for project implementation.

8. Training should also be provided for technical staff involved in development projects regarding the incorporation of environmental dimensions into project planning, design and implementation. This could be achieved through a short 1 or 2 day workshop.

9. ARA-Centro and ZIMWA should establish formal agreement with the agencies responsible for the environment (*viz*., the Ministry for the Co-ordination of Environmental Affairs and the Ministry for the Environment and Tourism respectively) regarding environmental assessment procedures for development projects in the Pungwe River basin in order to streamline approval. This could be achieved through a Memorandum of Understanding.

10. Similar links should be established with the National Directorate for Conservation Areas (in Mozambique) and the National Parks and Wildlife Authority (in Zimbabwe) to ensure that issues related to conservation areas are fully taken into account in Project planning, design and implementation within the basin.

9 REFERENCES

Anon. 1999. *Biodiversity and war: a case study of Mozambiqu*e. CD produced by IMPACTO and WWF(US)

Bell R H V (1983) *Decision-making in wildlife management with reference to problems of overpopulation*. In: *Management of large mammals in African conservation areas*. Ed R N Owen-Smith. Haum, Pretoria. 145-172.

Bell, R H V & J E Clarke. 1984. Funding and financial control. In: *Conservation and wildlife management in Africa. The proceedings of a workshop organised by the US Peace Corps at Kasungu National Park, Malawi, October 1984*. Eds: R H V Bell & E McShane-Caluzi. US Peace Corps, Washington DC.

Burlison, J, J Carter & T Williams. 1977. *Report to the Ministry of Agriculture on an investigation into some of the ecological problems of Gorongosa National Park, August-November 1977*. Centro de Ecologica, Instituto de Investigacão Cientifica de Mocambique.

COBA & PROFABRIL. Undated. *Esquema geral da bacia do Rio Pungoé, vol XII.*

DAI. Undated. *Policy options for people and protected areas*.

IGNFI-CENACARTA. 1999. *Carta de Uso e Cobertura da Terra*. Sheets 67 Beira and 72 Gorongosa.

IMPACTO. 1998. *The Biological Diversity of Mozambique*. Ministerio Para a Coordenaçäo da Acçäo Ambiental, Maputo.

IMPACTO. 2002. *Environment-based tourism assessment*. IMPACTO Lda - Projectos e Estudos Ambientais.

MacKinnon, J. 1994. *Analytical status report of biodiversity conservation in the Asia Pacific.*

Riney, T. 1977. *Major environmental problems in Mozambique*. UNEP, Nairobi.

SWECO, ICWS, OPTO, SMHI, NCG, CONSULTEC, UCM & Interconsult Zimbabwe. 2003. *Development of the Pungwe River Basin joint IWRM strategy: final inception report.* Janeiro, 2003.

Tinley, K. L. 1969. *The ecological limits of Gorongosa National Park, Mozambique: the maintenance of wilderness*. Report to the Mozambique Government (bilingual English/Portuguese).

Tinley, K L. 1971. Sketch of Gorongosa National Park, Mozambique. *Proceedings of SARCCUS Symposium 'Nature Conservation as a Form of Land Use'*. Govt Printer, Pretoria.

Tinley, K L. 1977. *Framework of the Gorongosa ecosystem.* Submitted in partial fulfillment of the requirements for the degree of DSc (wildlife management). University of Pretoria.

Appendix 1: Pungwe Basin Vegetation (Zimbabwe)

Introduction

The section of Zimbabwe within which the upper portion of the Pungwe River basin lies, is commonly referred to as the Eastern Highlands: it consists of a narrow belt of mountains and plateaus that range in altitude from 2 000 to 2 400 metres a.s.l., creating an abrupt escarpment along the border with Mozambique. The international boundary normally follows the watershed along this mountain chain but in some places it deviates from this line by linking two distant high points, thereby including within Zimbabwe some low-lying terrain at the eastern base of the escarpment.

The considerable elevation of the Eastern Highlands, coupled with high rainfall (exceeding 3 000 mm in places) creates microclimates and ecosystems that are unique in Zimbabwe, and which are of very limited surface extent. On the Agro-Ecological map of Zimbabwe, this high rainfall zone is classified as Natural Region 1. This region embraces the country's highest and most reliable rainfall area and is consequently suited to intensive land-use, particularly afforestation and horticulture. Much of the original vegetation and associated biodiversity in these very limited types of habitats has consequently been drastically reduced because of these areas (especially the montane grasslands and the lowland forests and woodlands) having been converted to agricultural usage.

T. Müller (1994) noted the following in his report:

> "Out of nearly 6 000 vascular plants recorded in Zimbabwe, about 740 occur in rainforest. They comprise 125 Pteridophytes, 3 Gymnosperms, 90 Monocotyledons (of which 46 are Orchidaceae and 17 are Poaceae), and 520 Dicotyledons. Only one endemic (*Swynnertonia cardinea*), and a few endangered species occur in them, and species richness is low compared with the forests of the equator region. Most of the species that are rare in Zimbabwe are common elsewhere. Nevertheless, conservation of the rainforest is considered to be of the utmost importance. Approximately 430 (almost 40%) of the 1 180 woody species recorded for this country are confined to the rainforest, 265 of which are trees with a diameter of at least 8 cm. Furthermore, the forests occur at the dry end of rainforest distribution and it can be assumed that unusual ecotypes and genotypes are contained in them. Apart from this, the forests are of great aesthetic value and are part of our national heritage. Because of this alone, efforts should be made to secure their survival. The protection of rainforest is also in line with our National Conservation Strategy (1978) that states that examples of all natural ecosystems and vegetation types should be protected."

These comments and sentiments apply equally well to the other floristic and faunal elements that occur in the other very limited vegetation types that exist in the Zimbabwe portion of the Pungwe River catchment.

Historical Perspectives of the Upper Pungwe Terrain

Prior to European settlement from 1890 onwards, this area of largely open cool temperate grassland, with occasional small patches of forest or scrub, had been sparsely inhabited in the past by indigenous African people. However, their terraced fields and circular sunken stone-lined livestock pits were abandoned about 300 years ago. When Cecil Rhodes first visited the area in the mid 1890's, he was so impressed by the beauty and potential of this relatively virgin area that he decided to acquire a number of the recently surveyed farms; these he later bequeathed to the nation as a National Park. Some of this land (Erin Forestry Estate) was later leased to the Forestry Commission and is now planted to Mexican pines (*Pinus patula*). Rhodes arranged for the initial trials of exotic trees, mainly pines and eucalypts, and he also introduced various deciduous fruit trees. Australian Black Wattle (*Acacia mearnsii*) was extensively planted for tannin extraction on similar adjacent land, mostly just after World War II. In addition, deciduous fruit (especially apples and peaches) were planted on a number of properties. The result is that commercial plantations and orchards have now obliterated most of the natural highland vegetation outside the Rhodes Nyanga National Park.

The very limited remnant of the original montane vegetation that now remains is therefore of special scenic and scientific significance. Regrettably, the remaining grasslands and stream banks are now being invaded by alien pines and wattle, thus further suppressing the indigenous flora and fauna. In times past, fires periodically swept these grasslands and kept back tree and shrub growth. With the advent of commercial forestry, uncontrolled veld fires became a serious hazard, prompting the introduction of firebreaks and controls on burning. Roads and orchards also provided additional constraints on unplanned fires. At one time, controlled burning was undertaken within the National Park in order to maintain the open grasslands, but this practice appears to have now ceased and undesirable shrubby species such as *Stoebe vulgaris* and *Athenasia acerosa* are on the increase. It used to be thought that recent veld fires and forest clearance by man were the sole reasons for the presence of the montane grasslands but studies by Tomlinson (1973) showed from the examination of pollen in soil deposits that around 12.000 years ago there were very few trees in the grasslands.

Due to the current lack of fires, the valley sides between the Pungwe Falls and the Pungwe causeway, which were open grassland up to the early 1960's, are now a rank and almost impenetrable shrubby tangle of *Hypericum revolutum*,

Freylinia tropica, *Buddleia salviifolia*, *Asparagus* sp., *Artemisia afra*, *Leucosidea sericea*, *Rubus rigidus*, etc., in which pines and wattle are also rapidly establishing themselves. The Cape Beech (*Rapanea melanophloeos*), a pioneer evergreen forest tree, is also expanding into this protected environment.

The upper Pungwe ecological factors

Unlike the rest of Zimbabwe, a light drizzle that is locally known as "guti", occurs here regularly in the dry season. The relatively low temperatures that prevail at the higher elevations, coupled with the dense vegetation cover that the high rainfall creates, reduces evapotranspiration losses. These two sets of factors have the effect of preventing much of the soil surface from drying out completely, thereby maintaining green foliage on many plant species in the dry season. The forests and montane grasslands that are supported by this locally increased precipitation contain many items of flora and fauna that are not found elsewhere in Zimbabwe. This montane region is very limited in extent and it is consequently necessary to ensure that what remains is given maximum conservation status and protection.

The vegetation of that portion of the Pungwe River Basin that lies within Zimbabwe is one of remarkable ecological diversity and scientific interest, all compressed into a very compact area. This is due to the great altitudinal range of almost 2000 m that varies from a maximum of 2593 m at the summit of Nyangani Mountain down to 580 m at Katiyo Tea Estate next to the Pungwe River on the Mozambique border, only 24 km away.

The nearly sheer 1500 m eastern face of Mt Nyangani, together with the similarly sheer cliffs of the Nyanga plateau escarpment that flank it along the western rim of the Honde Valley, cause the prevailing moist easterly winds from the Indian Ocean to rise and cool, thereby enabling the condensed moisture to fall as orogenic rain during most months of the year.

This range in altitude gives rise to wide climate and temperature ranges, from sub-tropically hot and humid at the base of the escarpment to cool and misty with winter frosts at the higher elevations. The amount of rainfall is determined by altitude and by proximity to the mountain, as well as by the aspect: the west- and north-facing slopes are the warmest and driest. South-facing ravines provide moist shaded microclimates suited to relict plants and fauna that are survivors from previous wetter and cooler eras.

In addition to altitude and climate, differences in the geology at different localities in the Pungwe Basin also dictate the species of plants that occur there. This is because the nature of the geology normally determines the

types of derived soil that overlie the basal rock: many species of plants have strong edaphic preferences and will only grow on certain soil types. The floor of the basin (mostly at altitudes of 600-800 m) is underlain by granitic rock, with occasional narrow dolerite dykes. Many of the low hillocks on the valley floor on the north side of the Honde and Pungwe Rivers, as well as in the Ngarura Valley adjacent to the border, are comprised of weathered white quartz derived from pegmatite veins, which is much in demand for surfacing local earthern roads. The soil depth on these hillocks is relatively shallow (under one metre).

Elsewhere in the valley the soils often attain depths of many metres and are comprised of very infertile red gibbsitic or kaolinitic clays that develop when granite weathers under a high rainfall in a sub-tropical climate (in Zimbabwe, granite usually gives rise to very sandy soils with a low clay and mineral content). These red clays are very compact: on agricultural test plots near Gatsi and Hauna, roots of annual crops such as cotton and maize were unable to penetrate into subsoil that had not been loosened by ploughing.

The bulk of the fertility in shallow topsoil that overlies mineral-poor granite is stored in the organic matter built up over many millennia under the dense canopy of the original woody and herbaceous vegetation. This humic layer is rapidly lost when traditional hand cultivation by shifting slash and burn agriculture is replaced by continuous annual ploughing because that then exposes the unprotected soil to solar radiation and to oxidization. In such cases, abandoned lands have remained bare and weedless for up to fourteen years after the resultant sheet erosion had removed all of their topsoil, such as happened when these were on sloping hillsides in areas like the Honde River catchment

The soils that are derived from dolerite are much more fertile, as also are the alluvial soils on flood plains like those along the Ruda River. Drainage lines have trapped nutrients leached from above, and the thicker vegetation and the moisture in these sites have promoted the development of dark humic-rich soils.

The valley floor on the south side of the Honde River in the Mutasa North Communal Land is much more sandy because it lies in the rain shadows of the high south rim of the escarpment and of the adjacent mountains on the Mozambique border (Banga). The drier climatic conditions in that part of the Basin encourage more normal weathering and decomposition of the underlying granite.

The rim and cap of the Honde Valley escarpment in the vicinity of the Mtarazi and Pungwe Falls is a very thick sill of dolerite, often with numerous porphyritic feldspar crystals. This sill overlies the basement granite and appears to have been intruded under an overlying Umkondo sediment layer

that has now been lost by erosion. This dolerite sill is a very hard fine-grained rock that is highly resistant to weathering and it therefore forms dramatic high cliffs and waterfalls along the Honde Valley escarpment. The cliffs of the dolerite sill terminate to the north of the spectacular sheer granite hill called Rakonde in the Manga Communal Area. This forms the northern extremity of the granite domes and ridges that flank the westerly and southerly end of the Honde Valley, as well as the Nyamkwarara Valley.

The basal granite is exposed at the southern base of Nyangani Mountain in the National Park but the dolerite sill appears to have been uplifted to form the south-facing crags and the cap. Occasional traces of Umkondo shales remain on the upper slopes, but are more extensive at the northern end of the Nyanga Downs. The basal granite underlies the tea plantations in the northern part of the Pungwe Basin and extends across to the Mozambique border north and south of Katiyo. Tangwena Mountain, just over the border north of Katiyo, is comprised however of a unique exposure of steeply sloping schist and will therefore have a different type of vegetation. It formerly had large populations of an endemic cycad (*Encephalartos tangwensis*) but most were brought across into Zimbabwe for sale. Other endemic plants can also be expected to grow there.

PUNGWE RIVER BASIN VEGETATION ZONES

Within the Zimbabwe portion of the Pungwe River basin, vegetation type is primarily dictated by the altitude, but in addition rainfall, geology, soil type and depth, rockiness, slope, aspect, temperature and frost are also major influences in determining where various species of trees, shrubs, and herbaceous plants can grow, all of which comprise and define the floristic nature of each ecosystem. These ecosystem differences, in turn, control the diversity of the associated flora and fauna by providing the habitats and food chains that support them.

The large variation in altitude of the Mt. Nyangani area, especially that of its eastern slopes which descend over 1 500 m without a break down into the Pungwe Valley, provides correspondingly large temperature and rainfall variations. A somewhat similar ecological catena is found in the adjacent Nyamkwarara Valley, but this commences at a much lower altitude, it is not as steep, and it is on granite so there will be many differences in the species content at each altitude level. The high rainfall and range of temperatures in both of these valleys is conducive to the growth of various types of forest and dense woodland.

The moist forests of Zimbabwe represent an important remnant of the discontinuous montane forest habitats down Africa, the majority of which are

currently very threatened. Together, these forest and montane zones represent an area of special biological and scenic importance to Zimbabwe. It is highly desirable that the whole of this very attractive and scientifically important area should be gazetted as a World Heritage Site. Any further damage or incursion into what remains of these unique forests and grasslands requires to be strenuously resisted. Furthermore, stream flows are known to decrease where indigenous vegetation is displaced by fast-growing exotic species.

The vegetation in the Pungwe catchment can be grouped into five broad altitudinal zones as follows, but exact delineation of each of the altitudes is not practicable, partly because there is always a cline in the changes of the species that are present, and also because localized topography and micro-climates can cause shifts of the altitudes at which certain species are prevalent.

Zone 1 Above 2150 m (7050 feet): The **Upper Montane Vegetation** which is restricted to the upper elevations of Mt Nyangani, and with possibly a very small extent on the summit of Banga, the peak on the Mozambique border that separates the Honde and Nyamkwarara valleys. Within the Pungwe catchment the upper montane terrain of Mt Nyangani is in turn sub-divided by aspect and topography into three main sub-groups:

1(a) the relatively drier Western Face vegetation (steep rocky shrub and grassland)

1(b) the Summit Plateau (rocky shrub and grassland, plus wet seeps and pools)

1(c) the wet precipitous forested Eastern Face

Zone 2 1650 m (5400 feet) to 2150m (7050 feet) : The **Lower Montane Vegetation** on the escarpment plateau extending from the western base of Mt Nyangani in the Rhodes Nyanga National Park (including the Pungwe River headwaters) and then along the rim of the Honde Valley past the Mtarazi Falls as far as the Mutasa district headquarters, and then resuming again on the Stapleford Forestry Estate (Nuza Mountain). Most of the region at this altitude lies in the mist-belt and is characterized by the widespread occurrence of bracken fern (*Pteridium aquilinum*) in suitable sites. An exception is the sugar-loaf peak Gorongo (Gurunguwe) on the Mozambique border at the northeast end of the Nyamkwarara Valley – this is a sub-tropical site, and is included under Zone 3A.

The **Lower Montane Vegetation** area embraces the following principal vegetation sub-divisions:

2(a) Afro-Montane Heather-Grassland

2(b) Montane evergreen forests (as classified by Müller, 1994)

2(c) High Wetlands

Zone 3 1300 m (4250 feet) to 1600 m (5400 feet): Because of the range in rainfall according to the proximity or distance from Mt Nyangani and other high elevations, vegetation in this altitude zone falls into two categories:

Zone 3A - **Submontane vegetation**, which occurs in high rainfall areas on the lower slopes of the Nyangani Massif and around the Pungwe Gorge, and also in the upper parts of the Nyamkwarara Valley on Stapleford. This includes patches of evergreen forests of which Müller recognised four types:

3A(a) Mixed sub-montane forest

3A(b) *Craibia brevicaudata* forest

3A(c) Mixed Albizia regenerating forest

3A(d) *Albizia schimperiana* forest

Additionally, this vegetation zone contains:

3A(e) Mixed semi-evergreen woodlands

Zone 3B - The **Zimbabwe Highveld vegetation**, and which forms an eastern extension of the Zimbabwe watershed ecosystems. It occurs on the plateau above the rim of the Honde Valley in a lower rainfall area than Zone 3A and extends from Mutasa district headquarters to Watsomba and thence along the south rim of the Honde Valley to Odzani and up to the western edge of the Stapleford Forestry Estate. This altitudinal zone encompasses three main vegetation sub-groups

3B(a) Miombo woodland

3B(b) Highveld grassland

3B(c) Highveld wetlands

Zone 4 900 m (3000 feet) to 1300 m (4250 feet): The **Escarpment Slope vegetation** is on the slopes and foothills of the escarpments and ridges around the edge of the Pungwe, Honde and Nyamkwarara basins: its composition at any site depends on the amount of orogenic rainfall that is deposited when moist easterly winds encounter and ascend the escarpment. The areas that lie just below the highest elevations receive the greatest precipitation, and the vegetation types vary accordingly. The following are the principal rainfall-dependent vegetation subdivisions within this altitudinal zone, all of which comprise forest or dense woodland. The evergreen forests in this zone were classified as 'Medium altitude forests' by Müller in his 1994 report.

4(a) High rainfall

4(b) Medium rainfall

4(c) Low rainfall

Zone 5 600 m (2000 feet) to 900 m (3000 feet): **Lowland vegetation** occurs on the floors of the Pungwe, Honde, Ngarura, and Nyamkwarara valleys and it extends over the border into Mozambique. This vegetation type becomes progressively drier as one moves eastwards or southwards away from the influence of Nyangani Mountain and into the rain shadow area of the Honde basin that is created by the Banga ridge, along which runs the international border.

The vegetation zone compositions

Within each of the major altitudinal zones of the Zimbabwe portion of the Pungwe River Catchment there are a variety of local ecosystems. Details of the principal components of the vegetation that is found in each of these five altitudinal zones are provided below. However, the continuous nature of the forest down the moist eastern face of Mt. Nyangani is such that it is not possible to rigidly separate the various altitudinal facies because different species gradually appear or disappear as one proceeds either up or down the mountainside.

Prior to the opening up of the tea estates, as well as the enormous expansion by communal area farmers into the formerly largely virgin areas at the lower altitudes over the past few decades, there was an uninterrupted continuum of evergreen forest from below the summit of Nyangani Mountain at around 2100 m, all the way down to the base of the escarpment at about 900 m (this forest catena also extends southwards towards the Pungwe and Mtarazi Falls wherever slopes are not too precipitous). Below this altitude it merges with dense semi-deciduous *Uapaca*, *Brachystegia* and *Albizia* woodland and bamboo (*Oxytenanthera abyssinica*) towards the Mozambique border at Katiyo Tea Estate, at an elevation of about 600 m. Although now very reduced in extent, the forest on the eastern slopes of the Nyangani Massif constitutes the largest area of true closed-canopy evergreen forest that remains in Zimbabwe. A very similar large patch of forest occurs up the western slope of the Nyamkwarara valley on Stapleford Forestry Estate.

Zone 1 - The **Upper Montane Vegetation** occurs above 2150 m (7050 feet), mostly on dolerite but with occasional small residual lenses of shale. Banga Mountain is granite and will therefore have a different suite of plant species on its summit, but due to inaccessibility it has not been explored. The Nyangani montane complex comprises:

1(a): the drier Western Face vegetation - steep rocky grassland with patches of fynbos. The grasses are short and usually tussocky, and are intermingled with a wide variety of low-growing perennial herbs (often aromatic), including the endemic *Otiophora inyangana*, *Helichrysum nitens*, *Schistostephium artemisifolium*, *Crassula* spp., *Plectranthus* spp., *Hemizygia teucriifolia*, *Walafrida goetzei*, *Graderia scabra*, *Hebentretia oatesii* ssp. *inyangana*, and *Alepidea swynnertonii*. The fynbos shrubs comprise items such as the 2 m tall bushes of *Erica (Philippia)* spp., the rare *Protea asymmetrica* and the more widespread *P. welwitschii* and *P. (caffra ssp.) gazensis*. *Aloe collina* is a rare Inyanga endemic. On rock and boulder patches, stunted trees and bushes of *Widdringtonia nodiflora* occur in fire-protected sites

1(b): the Summit Plateau (rocky shrub and grassland, plus wet seeps) has a number of very rare or endemic species such as *Protea inyanganiensis*, *Dierama formosum*, *Erica woodii*, *Aloe inyangensis*, and *Disa rhodantha*. Clumps of grey-leafed *Helichrysum* spp. are common, and *Disa fragrans*, *Moraea carsonii*, and *Indigofera dimidiata* are among the many attractive flowers among the rocks and grasses. *Cyrtanthus breviflorus* is a South African plant that has only been found at three sites in Zimbabwe, around high altitude seeps. A *Kniphofia* (Red-hot Poker) that resembles a small form of *K. linearifolia*, is apparently an undescribed new species. In recent years a few pines have now started to grow from wind-borne seed. The summit is the sole home of the endemic brown Nymphalid butterfly *Pseudonympha arnoldii* but occasional strays have been seen at World's View on the Nyanga Downs.

1(c): the upper portion of the precipitous wetter forested Eastern Face is too steep and inaccessible for any survey to be easily undertaken of the vegetation that occurs there. It may well contain rare or endemic species because similar conditions are not encountered anywhere else in Zimbabwe.

Zone 2 - 1650 m (5400 feet) to 2150 m (7050 feet) : This is the **Lower Montane Vegetation** on the escarpment plateau that extends from the western base of Mt Nyangani in the Rhodes Nyanga National Park and which includes the Pungwe River headwaters to the Pungwe Falls and then along the rim of the Honde Valley past the Mtarazi Falls to the Mutasa district headquarters, and then recurs again on the Stapleford Forestry Estate. This region lies in the mist-belt on very leached siallitic soils and is characterized by the widespread occurrence of bracken fern (*Pteridium aquilinum*), often on disturbed areas. Outside of the National Park area, most of the former grasslands have been converted to exotic tree plantations, now mainly pine (principally *P. patula*, but also some *P. elliotii*) but many of these estates were previously under Black wattle (*Acacia mearnsii*). Narrrow strips of grass still occur as firebreaks and alongside roads and streams, but often the grass is *Eragrostis acraea*.

This area embraces the following principal vegetation sub-divisions:

2(a) The Afro-Montane Heather-Grassland

2(b) The Montane forests

2(c) High Wetlands

The more important components of these are as follows:

2(a) The Afro-Montane Heather-Grassland

This vegetation type, which lies at an altitude of 1650 - 2150 m, is mostly confined to the lower western slopes of Mt Nyangani and the adjacent rolling hills and valleys that lie within the Rhodes Nyanga National Park above the rim of the escarpment. In the more moist sites close to the escarpment, which are subject to frequent mists and rain, bracken ferns (*Pteridium aquilinum*) often dominate the tussock grassland. This grassland comprises a mixture of pioneering *Eragrostis acraea* (Nyanga Tussock Grass) and various species of yellow-flowered *Helichrysum* (Everlastings). The small shrubby tree *Leucosidea sericea* is found along the watercourses and stream-banks where it occurs in conjunction with the very attractive purple-flowered Royal Dissotis (*D. princeps*), the yellow-flowered *Hypericum revolutum* (Curry Bush), *Freylinia tropica* (Nyanga hedge bush), *Passerina monticola*, and Tree ferns (*Cyathia dregei*). *Protea welwitschii* and *P.* (*caffra* ssp.) *gazensis* dot the higher rocky slopes.

Hypericum revolutum, which favours rank mountain grassland, as well as streambanks, watercourses and the margins of evergreen forest, is often a pioneer to forest in plant succession where conditions for forest growth are suitable, and is therefore ecologically important.

On the hillsides along the upper Pungwe River, the heather *Blaeria friesii* forms sheets of mauve-purple in late summer, contrasting with the low grey bushy mounds of *Helichrysum splendidum, H. mimetes* (Curry Flower), and *Stoebe vulgaris*. On the more shallow and drier soils on open hills further from the escarpment edge, *Loudetia simplex* and *Monocymbium cerisiforme* are two of the most common grasses. In some sites, especially on the higher or wetter undisturbed ones, *Themeda triandra*, *Elyoneurus argenteus, Bewsia biflora, Rendlia altera* and *Tristachya hispida* are the dominant species, with various species of *Cymbopogon* (*C. validus, C. caesius* and *C. cymbiformis*) occurring in rank hollows. Much of this montane short open grassland is possibly a fire sub-climax, and it becomes invaded by pioneer shrubs in the prolonged absence of fire. The Nyanga Tussock Grass (*Eragrostis acraea*) is a pioneer on disturbed soils such as on roadsides and is able to survive well under pine and wattle plantations. It is often the dominant species over extensive areas, such as in the Temburutedza River basin – a probable indication that the entire area had been cultivated in ancient times.

A variety of colourful terrestrial orchids occur in the wetter or rocky parts of these grasslands in late summer, mainly species of *Satyrium*, *Disa*, and *Habernaria*. The rare *Gladiolius zimbabweensis* occurs in grassland at the western foot of the mountain, and this habitat is shared by the diminutive *Aloe myriacantha*. The very attractive pink *Gladiolus crassifolius* favours slightly

more rocky ground, and the two Harebells (*Dierama formosum* and *D. inyangense*) share similar sites. The harebells, aloe, and the orchids are gazetted as Specially Protected Species. In spring, burnt grassland is flushed with a colourful variety of flowers, such as the two species of red Fire Lilies (*Cyrtanthus contractus* and *C. rhodesiensis*), the blue *Pentanisia variabilis*, pink *Indigofera hilaris*, pink *Otiophora inyangana*, and many others. Three species of *Hypoxis* ('African potato') utilize various ecological niches in the grasslands, of which *H. obtusa* is the most widespread, the diminutive *H. angustifolia* occurs on the more exposed slopes on shallow soils, and the endemic *H. pungwensis* in wetter sites.

These moist open grasslands are also the habitat of various rare or endemic birds and butterflies, such as the endangered Blue Swallow (*Hirundo atrocaerulea*), the local race of the African Quail (*Coturnix africana erlangeri*), and the endemic blue Lycaenid butterflies *Lepidochrysops coxii, L. ruthica*, *L. violetta*, and *L. inyangae*, and also *Aloeides plowesii*, a small endemic brown Lycaenid butterfly.

The tussock grasslands, as well as the scrubby steep hillsides of the upper Pungwe River above the Pungwe Falls, are being seriously invaded by feral Mexican Pines (*Pinus patula*) and by the Australian Black Wattle (*Acacia mearnsii*); both of these are extensively grown in adjacent commercial forestry plantations. Germination of the seeds of wattle is promoted by fire. They can lie dormant on the soil surface for a number of years until a fire scorches the tough seed coat and allows penetration of water, which initiates germination. Pine seed is carried long distances by high winds.

2(b) Montane forests (as designated by T. Müller in his 1994 report for the Forestry Commission), refer to the evergreen rain forests that occur in the zone between 1650 m and 2050 m (but which is designated in this present Pungwe report as Lower Montane). He recognized six types of forest in this altitude zone:

Syzygium masukuense montane forest, occurring between 1700 m and 2050 m. This tree occupies up to two thirds of the cover in the wetter sites. Other common trees are *Aphloia theiformis, Cassipourea malosana, Ilex mitis, Podocarpus latifolius, Prunus africana, Rapanea melanophloeos,* and *Schefflera umbellifera*. The sapling and shrub layer encompasses *Canthium oligocarpum, Diospyros whyteana, Dovyalis lucida, Erythrococca polyandra, Pavetta umtalensis, Peddiea africana, Psychotria zombamontana*, and *Justicia betonica*. In drier sites, the *Syzygium* is less common and *Curtisia dentata, Macaranga mellifera,* and *Maesa lanceolata* become more frequent. At the lower altitudes in this forest type, other species intrude such as *Cryptocarya transvaalensis, Faurea racemosa, Olea hochstetteri, Pterocelastrus echinatus*,

and *Tabernaemontana stapfiana*. At the higher altitudes, the tree height is 10-12 m, increasing to 15-20 m further down.

Afrocrania volkensii montane forest is very limited in distribution on Nyangani Mountain (but more extensive on the Chimanimani range) with a canopy height of up to 30 m. It occurs on wet boulder screes in the high valleys. Other common trees are *Ekebergia capensis, Kiggelaria africana*, and *Prunus africana*. In the ill-defined secondary layer, the shorter trees are *Calpurnia aurea, Canthium pauciflorum* ssp. *angustifolium, Diospyros whyteana, Halleria lucida*, and *Trimeria grandiflora*.

Widdringtonia nodiflora forest is very limited in the Eastern District mountains, and is found between 1700 and 2100 m along rocky streams in valleys in rain-shadow areas. The trees seldom exceed 10 m in height and are often in pure stands in more favoured areas, but may become thickets intermingled with occasional specimens of *Curtisia dentata, Ilex mitis, Maesa lanceolata, Macaranga mellifera, Nuxia congesta, Rapanea melanophloeos*, and *Schefflera umbellifera*.

Ilex mitis - Schefflera umbellifera - Maesa lanceolata montane forest occurs between 1700 and 2100m in small drier situations than *Syzygium* dominated forest can tolerate. It is very variable in its species composition, and may contain any of the following as co-dominants: *Aphloia theiformis, Curtisia dentata, Faurea racemosa, Podocarpus latifolia*, and *Rapanea melanophloeos*.

Syzygium guineense ssp. *afromontanum* forest occurs below the level of the *Syzygium masukuense* forest, from 1900 m down to as low as 1500 m in some sites, and is usually the dominant forest type there unless subject to past disturbance. Canopy height ranges from about 12 m at the higher altitudes, increasing to 20-25 m tall further down, with some emergent trees attaining 30 m. Other important trees in this forest type are *Aphloia theiformis, Cassipourea malosana, Cryptocarya transvaalensis, Olea hochstetteri, Pterocelastrus echinatus*, and *Rapanea melanophloeos*, but also common are *Apodytes dimidiata, Bersama swynnertonii, Croton sylvaticus, Ekebergia capensis, Ilex mitis, Kiggelaria africana*, and *Nuxia congesta*. There is a well-developed sub-canopy layer comprising *Tabernaemontana stapfiana, Dovyalis lucida, Erythroxylum emarginatum, Eugenia nyassensis, Oxyanthus speciosus, Pavetta umtalensis, Rawsonia lucida, Xymalos monospora, Chionanthus foveolatus* ssp. *major, Ochna holstii*, and *Oricia bachmanii*. The shrub layer is usually dominated by *Psychotria zombamontana, Justicia betonica, Peddiea africana*, and *Sclerochiton harveyanus*.

Regenerating montane forest is common in the Nyanga area where former *Syzygium* rain forest has been cleared in the past. It comprises pioneer species such as *Macaranga mellifera, Aphloia theiformis, Maesa lanceolata*,

and *Schefflera umbellifera*. *Polyscias fulva* and *Allophylus abyssinica* can also be common, especially at lower altitudes. The presence of *Cassinopsis tinifolia, Hypericum revolutum*, and *Myrica pilulifera* indicate young regenerating forest.

The branches of the trees in all these forest are usually festooned with mosses and epiphytic ferns of the family *Polypodiaceae* such as *Pleiopeltis excavata*, and they also support various epiphytic orchids such as *Mystacidium gracile*, *Polystachya caespitifaca* ssp. *hollandii*, *Angraecum conchiferum* and *A. sacciferum*, all of which have very restricted distributions within Zimbabwe.

By virtue of its altitude requirements, true montane forest is found at only three areas in Zimbabwe, viz. Mt. Nyangani, Mt. Engwa (Himalayas) near Cashel, and in the Chimanimani range. (Most of the Vumba and also the Mt. Selinda forests lie at lower altitudes). The geology of each of these localities differs considerably, especially that of the Chimanimani range, so that these forests are not exact replicates of each other and each supports biota that are not encountered at the other localities.

Both the Montane and the Sub-montane Forests harbour the diminutive Blue Duiker (*Cephalophus monticola*) and the Bushpig (*Potamochoerus porcus*), as well as the occasional Leopard (*Panthera pardus*), but on the whole, the fauna of these forests is limited and imperfectly known.

2(c) High Wetlands are very limited in extent in the **Lower Montane Vegetation** in the altitude belt at 1650 m (5400 feet) to 2150m (7050 feet) but they are ecologically very important because they support flora and fauna that is not encountered elsewhere. Unfortunately, no systematic sampling appears to have been undertaken of the grasses, sedges, and other plants that occur in them. The most extensive of these wetlands are those that are situated on old meanders and oxbows in the perched upper Pungwe River valley above its junction with the Madzimawuya and Matenderere Rivers, and also the Duru River vlei on Wattle Company land on the plateau on either side of the road down to the tea estates. The latter was home to a pair of Wattled Cranes, as well as other uncommon birds such as Flufftails, Rails, Broad-tail Grass Warbler, and Grassbird, but no survey has been undertaken of the vegetation of these either. Since the removal of cattle that were formerly allowed to graze the Duru Vlei, reeds (*Phragmites mauritianus*) have proliferated, as also has the tall grass *Pennisetum glaucocladum*, and this has made the vlei untenable for the Cranes. *Koeleria capensis* is one of the shorter grass species. On the margins of the lower end of the Duru Vlei an exceptionally tall species of Red-hot Poker (*Kniphofia*) has been found that reaches a height of over 3 m: it may be a form of *K. splendida* but it has not yet been identified. It should be of great horticultural value, and needs propagation and protection.

Zone 3 1300 m (4250 feet) to 1650 m (5400 feet). Largely due to the substantial reduction in the rainfall with increasing distance from Mt Nyangani in this altitude zone, it is necessary to group the vegetation in it into two broad categories :

3A – Submontane, mainly in the wetter northern areas adjacent to Mt Nyangani, and

3B – Highveld in the more southerly drier section.

Zone 3A 1300 m (4250 feet) to 1650 m (5400 feet): **Submontane vegetation** occurs in high rainfall areas on the lower slopes of the Nyangani Massif and around the Pungwe Gorge, and also on hillsides in the upper parts of the Nyamkwarara Valley on Stapleford in this altitude zone. This comprises medium altitude evergreen forests of which Müller recognised four types:

3A(i) At the higher levels in this zone, Mixed sub-montane forest is usually characterized by a combination of *Cassipourea malosana, Nuxia congesta, Oricia bachmanii, Podocarpus latifolius, Rapanea melanophloeos*, and *Syzygium guineensis* ssp. *afromontanum* as canopy trees. Sub-canopy species are *Aphloeia theiformis, Diospyros whyteana, Erythroxylum emarginatum, Ochna holstii, Oricia bachmannii, Oxyanthus speciosus, Tabernaemontana stapfianus*, and *Xymalos monospora*.

At medium altitude levels though, *Cassipourea gummiflua, Chrysophyllum gorungosanum, Craibia brevicaudata ssp. baptistarum, Ficus chirindensis, F. craterostoma, F. scassellati*, and *Strombosia schefflerii* are common. *Croton sylvaticus* is frequent at all levels and *Ekebergia capensis* is often present too. *Bersama swynnertonii* and *Margaritaria discoidea* ssp. *nitida* are mainly confined to this forest category. At this lower altitude the principal sub-canopy species are *Cola greenwayi, Englerodendron magalismontanum, Garcinia kingaensis, Heinsenia diervilleoides, Myrianthus holstii, Rawsonia lucida, Rothmannia urcelliformis*, and *Vangueria esculenta*, but all of these vary in frequency.

The shrub layer comprises *Justicia betonica, Psychotria zombamontana, Peddiea africana*, and *Sclerochiton harveyanus* but up to 50 species have been recorded in a small sample plot.

Canopy height for these forests can reach 25-35 m, with some emergents attaining 40 m. This forest group has the greatest species diversity in Zimbabwe, with 41 different types of trees being found in a 0.25 ha plot.

A survey undertaken by Dr. Tom Müller some years ago in the middle reaches of the Pungwe Gorge indicated that even in this remote and inaccessible area much of the original forest in these reaches had previously been felled for cultivation and was now largely comprised of secondary growth. Fortunately, the portion of the gorge nearest to the Pungwe Falls is apparently considered sacrosanct and is left undisturbed.

3A(ii) *Craibia brevicaudata* forest is fairly rare on granite boulder screes at 1400-1600 m. The canopy is usually 20-25 m, but reaches 30 m, with emergent figs up to 35 m. In addition to *Craibia brevicaudata* ssp. *baptistarum*, it also has *Ficus chirindensis* and *F. scasselatii* as main associates, and lesser numbers of *Cassipourea malosana, C. gummiflua*, and *Croton sylvaticus*. The most common sub-canopy species are *Dracaena steudneri, Rothmannia urcelliformis, Teclea nobilis*, and *Ritchiea albersii*. *Dracaena fragrans, Metarungia pubinervia*, and *Peddiea africana* occur in the shrub layer.

3A(iii) *Mixed Albizia regenerating* forest replaces regenerating forest below 1600 m, and is characterized by having both *Albizia gummifera* and *A. schimperiana* as dominants, with the former being more common in wet areas, and the latter in drier ones. Canopy height is 40 m or more. Other common canopy trees are *Celtis africana, Croton sylvaticus, Polyscias fulva, Rauvolfia caffra, Sapium ellipticum*, and *Macaranga mellifera*. *Teclea nobilis* and *Xymalos monospora* are the most common of the smaller trees.

3A(iv) *Albizia schimperiana* forest is the driest type of rain-forest – in drier situations, it is replaced by miombo, often abruptly. It is usually accompanied by *Allophyllus abyssinicus, Celtis africana, Ekebergia capensis, Ficus sur*, and *Prunus africana*. Lower story trees are *Dracaena steudneri, Kiggelaria africana, Ochna holstii, Pittosporum viridiflorum, Trimeria grandifolia*, and *Xymalos monospora*. At the drier end of this forest type can be found trees such *Calodendrum capense, Erythrina lysistemon, Fagaropsis angolensis, Ficus thonningii, Olinia vanguerioides, Scolopia zeyheri, Schrebera alata*, and *Terminalia gazensis*.

Additionally, this vegetation zone contains:

3A(v) Mixed semi-evergreen forests which occupy the areas between the evergreen forest patches in the vicinity of the Pungwe Gorge and south towards the Mtarazi Falls, as well as in the Nyamkwarara Valley, and within which there are exposed tangles of various shrubby species, including *Philippia* (*Erica*), *Hypericum revolutum*, *Buddleja,* and *Freylinia*, often with *Smilax angustifolia*, and underlain by carpets of *Lycopodium clavatum, L. cernuum*, and other moss species. These areas are possibly transitional to evergreen forest. The trees are usually *Rapanea melanophloeos*, *Myrica* spp., *Macaranga mellifera*, *Maesa lanceolata*, *Mussaenda arcuata*, and *Aphloia theiformis*.

The vegetation of the hill-slopes in the Nyamkwarara Valley on Stapleford Forestry Estate differs from that of equivalent elevations in the Honde and Pungwe Valleys, largely because of being based on granite and with greater precipitation. These slopes are more sheltered too from dessication by sun and wind. The slopes are usually clothed in *Loudetia simplex* grassland that contains patches of *Parinari curatelliformis* and *Brachystegia spiciformis*, as well as bracken, at medium altitudes (900 – 1600 m), with *Syzygium cordatum* along streams. Numerous epiphytic and terrestrial orchids occur in this zone.

On the slopes of the east-facing valley below Mt Rupere, to the south of the John Meikle Forestry Research Station, there is a large and well-preserved evergreen forest, ranging in altitude from about 1800 m down to1300 m. Müller (1994) classified the upper region of this large forest as Regenerating Forest mixed with what he had termed *Syzygium guineense* ssp. *afromontanum* Montane Forest. Further down the slope it becomes Mixed Sub-Montane Forest containing a lot of *Podocarpus latifolius* and *Bersama swynnertonii* which is usually a rare tree elsewhere. *Craibia brevicaudata* Forest is found in that vicinity on boulder screes. About halfway down the slope the forest changes to Sub-Montane Regenerating *Albizia* Forest that contains very large specimens of *Albizia gummifera*. Towards the bottom end of the slope it becomes Mixed Sub-Montane Forest, and finally terminates as Medium Altitude Forest.

Below the dramatic bare sugar-loaf granite peak called Gorongo (also known as Gurunguwe) that marks the border on the eastern side of the valley, a patch of Medium Altitude Forest contains (or used to contain) many specimens of the endangered cycad *Encephalartos manikensis*. The forests at the base of this peak have however not been investigated, but are likely to contain many items of interest.

Zone 3B 1300 m (4250 feet) to 1650 m (5400 feet): This embraces **Zimbabwe Highveld vegetation** types that are an eastern extension of the Zimbabwe watershed ecosystems. These categories occur at a lower altitude and often in a much lower rainfall zone than the preceding ecosystems. They extend from the Mutasa district headquarters southwards to Watsomba and thence along the south rim of the Honde Valley along the road to Odzani, and finally across to the western edge of the Stapleford Forestry Estate. This altitude zone category encompasses four main vegetation sub-groups:

3(a) Miombo woodland, which has a patchy and limited distribution within the basin but is very widespread in the northern half of Zimbabwe. Within the Pungwe study area, it is mostly found on the slopes of the escarpment below the south rim of the Honde Valley, as well as on the Odzani plateau above; from there it extends southwards towards the Watsomba - Penhalonga road. On the higher ground, *Brachystegia spiciformis* ('Msasa') is the major constituent, and at the highest elevations, it is very stunted. Often, not many other plants compete with these trees, but the fern *Asplenium aethiopicum* usually forms dense colonies under them at the higher and wetter elevations. Also at the higher altitudes, the yellow-flowered *Senecio deltoideus* is another common associate, as well as a species of Petrol Bush (*Philippia/Erica*).

Many species of macrofungi are associated with Miombo woodland, of which several are highly prized such as *Amanita zambiana* ('Nhedzi'), orange and tan Chanterelles (*Cantharellus*) and the brown *Lactarius kabansus*. Streambanks are lined with Waterberry trees *Syzygium cordatum*, often accompanied by *Dissotis princeps* in wetter sites. At lower and drier sites, *Julbernardia globiflora* ('Mnondo') is a common associate tree. Grass cover is usually very poor in Miombo woodland, depending on land form and soil depth, but typically is sparse and comprises *Eragrostis* spp., *Digitaria* sp., *Sporobolus* sp., *Cymbopogon* sp., and *Hyparrhenia* sp. On poor or degraded soils, especially those underlain by a compact quartz gravel layer, *Helichrysum kraussianum* is very common, and in drier sites *Dodonea angustifolia* bushes are also frequent.

3(b) Highveld grassland: Much of this zone that occurs within the Pungwe basin was originally dominated by Thatch Grass (*Hyparrhenia* spp.) but is now largely under cultivation to maize because it lies within heavily settled communal lands, or else it is very heavily grazed. In the basin area the grassland occurs on red sandy clay loams over granite with dolerite dyke intrusions, and lies on the dissected peneplain above the Honde Valley. The Communal Land between Mutasa village and Kukwanisa farm school was previously part of the Wattle Company's estate ('The Downs') and some of it had been planted to wattle prior to acquisition by Government in the early 1970's for the settlement of families who were to be moved from the Nyamkwarara Valley.

Areas within the communal lands that are set aside as grazing areas contain *Hyparrhenia* sp., *Perotis patens, Digitaria* sp., *Eragrostis* spp. and *Sporobolus pyramidalis*. However, woody species such as *Brachystegia spiciformis*, *Julbernardia globiflora*, *Dichrostachys cinerea*, *Syzygium cordatum*, *Carissa bispinosa*, *Dovyalis caffra*, *Lannea edulis*, *Vangueria infausta*, *Annona* spp., and *Erythrina latissima* can also be found as scattered or clustered shrubs or trees in these grasslands and in their drainage lines.

Wild fig trees (mainly *Ficus sur*) are widespread but scattered in the grassland areas, as also is *Erythrina latissima* (these occur mostly in the grasslands between Mutasa and Watsomba). Some of the exposed granite hills have small populations of the endangered tall handsome Zimbabwe form of *Aloe pretoriensis*. These are being destroyed by livestock that browse on them. On the bare granite whale-back hills, the attractive Aloe *chabaudii* and seemingly dead blackened plants of *Xerophyta villosa* are often found.

3(c) The Highveld wetlands are now very reduced in extent by garden encroachment and most are now virtually non-existent due to overgrazing and resultant erosion and the lowering of the water table, especially all those in the Communal Lands. They used to be the habitat of Crowned and Wattled Cranes up till about 1960, when political and population pressures caused them to be opened up for grazing. Grasses that are frequently encountered in those vleis that have not been too severely degraded are *Acroceras macrum, Hemarthria altissima, Leersia hexandra*, and *Eulalia geniculata*. The 2 m tall reedy grass *Pennisetum glaucocladum* forms thick stands in protected streambeds.

Zone 4 900 m (3000 feet) to 1300 m (4250 feet): The **Escarpment Slope vegetation** varies in content and type according to the height of the cliffs and mountains that tower above them: their heights determine the amount of orogenic rainfall that is deposited when moist easterly winds encounter and ascend the escarpment. The vegetation that lies below the highest elevations in the vicinity of Mt Nyangani receives the greatest precipitation, whereas the slopes on lower sites to the south of the Honde River are the driest and comprise Miombo woodland with *Brachystegia spiciformis, B. boehmii*, and *Julbernardia globiflora*.

Some evergreen forest patches are found on the slopes in this altitude zone and are classified by Müller as Medium Altitude Forest. They occur on the east-facing slopes and foothills of the escarpments and ridges of the Pungwe Valley and in the Nyamkwarara Valley. This category of forest is very limited in the Pungwe region, comprising a few small remnants of former larger forests above the Pungwe Gorge at its confluence with the Nyazengu Gorge, and also at the upper levels of the Eastern Highlands and Aberfoyle Tea

Estates. They are characterised by species such as *Chrysophyllum gorungosanum*, *Craibia brevicaudata* var. *baptistarum*, and *Trichilia dregeana. Newtonia buchananii* and *Maranthes goetzeniana* are sometimes the dominant species. Other common canopy species are *Celtis gomphophylla, Croton sylvaticus, Diospyros abyssinica, Drypetes gerrardii, Ficus chirindensis, F. scassellatii, Khaya anthotheca* (=*nyassica*), and *Strombosia scheffleri*. The sub-canopy contains *Cassipourea malosana, Cola greenwayii*, *Englerodendron magalismontanum*, *Heinsenia diervilleoides, Myrianthus holstii, Oricia bachmanii, Pleiocarpa pycnantha, Rawsonia lucida, Rothmannia urcelliformis, Strychnos usambarensis, Suregada procera, Trilepisium madagascariense*, and *Vangueria esculenta*.

Regenerating areas of this forest are similar to the above forest type and include *Albizia gummifera*, *A. adianthifolia*, *Celtis africana*, *Croton sylvaticus*, *Polyscias fulva*, *Rauvolfia caffra*, and *Sapium ellipticum*, but with the addition of *Cordia africana* and *Harungana madagascariensis*. The first two of these trees are partially deciduous. In the more open areas at this altitude, *Parinari curatellifolia* is the woodland dominant, with dense stands of herbs and grasses (especially *Melinis minutiflora*). Most of this has now been cleared for maize and tea production by small-scale farmers and the commercial tea estates.

On various ridges in the Pungwe Valley, such as the Rureche and the Mandeya Ranges, the Manica Cycad (*Encephalartos manikensis*, a rare Specially Protected Species) formerly occurred in limited numbers but these have probably all been poached for sale. It is possible that specimens may still occur in the sacrosanct upper sections of the Pungwe Gorge. The Pungwe Gorge is the only locality in Zimbabwe where the Staghorn Fern (*Platycerium alcicorne* - a Specially Protected Species) has been recorded.

Zone 5 600 m (2000 feet) to 900 m (3000 feet) : The **Lowland vegetation** is that which is found in the Pungwe, Honde, Ngarura, and Nyamkwarara valleys below 900 m and which extends over the international border into Mozambique. This is progressively drier as one moves eastwards or southwards away from the influence of Nyangani Mountain and into the rain shadow in the Honde basin that is created by the Banga ridge. It formerly consisted of mixed closed-canopy regenerating semi-deciduous woodlands and bamboo (*Oxytenanthera abyssinica*) but is now largely under maize and other crops.

As in most of the preceding cases, there is no sharp differentiation between the various arbitrarily designated forest types in it except for a small patch (now but a pitiful remnant) of 40-50 metre tall trees (mostly *Newtonia buchananii*) of the Pungwe Forest at the bridge on the road to the Eastern

Highlands and Aberfoyle Tea Estates, as well as the discontinuous small remaining nearby patch above the Rumbizi Tea Estate in the Holdenby Communal Area; however, this is also steadily being encroached upon. The magnificent 4 sq. km tall lowland forest that had formerly occupied this whole area was felled and burned about 1953/55 when new persons moved in once a road and bridge had been constructed to the newly started tea estates.

These two patches had formed part of a continuous expanse of forests and dense woodlands in the Pungwe valley lowlands until Holdenby was acquired by the Government for African settlement in the early 1950s. Prior to that date, there were only 12 kraals in the entire area on either side of the Pungwe River.

The patch at the Pungwe Bridge was further decimated as a gesture of political defiance in the early 1970s, and since Independence it has been further encroached upon. It had been gazetted as a Protected Forest in 1975, but was degazetted by National Parks after Independence on the pretext that there was no longer enough of it left to justify protecting.

The supposed fertility of the soil in lowland subtropical forests was thought to be proven by the enormous size of the *Newtonia buchanani* and other trees that dominated it, and this led to the bulk of the forest being felled and burnt in the prevailing slash and burn culture of the time, leaving just these two small remnants. People are currently still expanding into the last vestiges of this forest and are planting maize there.

The development of the two commercial tea estates (Eastern Highlands and Aberfoyle) that commenced in the early 1950s led to the removal of most of the indigenous vegetation (largely *Parinari curatellifolia, Albizia* spp. and *Harungana madagascariensis*) on those properties. Fortunately, the riverine forests were left intact and undisturbed on these estates, as well as the closed canopy eevergreen forest patches on the steepest slopes.

Lowland Forest in the Pungwe Basin comprises two main types of forest as follows:

a) Tall *Newtonia* Forest

As the name implies, this spectacular forest type was dominated by 40 to 50 m tall trees of *Newtonia buchananii* that form an almost complete canopy. *Anthocleista grandiflora* is a common sub-canopy tree and *Aida micrantha* is the main shrubby species within the forest. The outskirts of these forests were protected in the main by *Harungana madagascariensis* and other forest precursors. The remnants of this forest type are being invaded by *Lantana*

camara, but where this has not yet taken over, dense stands of one to two metre tall *Newtonia* seedlings are growing in the clearings where mature trees were toppled in 1985 in a cyclone. These, if given adequate protection, could ultimately help in the re-establishment of the forest but they lack their normal protective fringe of shorter pioneer species (mainly *Harungana*). The last remnants of this magnificent form of forest are now being invaded and maize is being planted in clearings in and around it. It will soon all be gone.

In addition, a unique small forest of *Syzygium cordatum* and *Macaranga capensis,* with an understorey of *Afromormum albiflorum,* grew nearby at the junction of the Nyamingura and Pungwe rivers but was converted to maize fields about 1992.

b) Mixed Species Forest

This comprises the regenerating patches of former *Newtonia* Lowland Forest, and contains *Macaranga capensis, Anthocleista grandiflora, Syzygium cordatum, Newtonia buchananii* and *Albizia adianthifolia* as the principal constituents, with the wild ginger *Afromormum albiflorum* often forming a thick herb layer inside the forest. *Harungana madagascariensis* is the principal pioneer species on the forest margins. Unfortunately, much of this vegetation type is now being taken over by new cultivation, with consequent loss of all the constituent flora and fauna.

c) Lowland Riverine Forest

In addition to the two foregoing lowland forest types, a further very important forest type occurs along the lower sections of the Pungwe River and its major tributaries. This Riverine Forest is characterised by large trees of *Newtonia buchananii*, *Trichilia emetica*, *Khaya anthotheca* (formerly *K. nyassica*), and *Albizia adianthifolia*. A similar narrow strip of riverine forest lines the banks of the Nyamkwarara River. On rocky stream and river-banks, *Breonadia salicina* (=*Adina microcephala*) attains large dimensions, and the protected Royal Fern (*Osmunda regalis*) also occurs there. Locally common is the interesting rare climbing fern *Lygodium kerstenii* that often forms thick tangles. Tragically, most of the riverine forest in the Holdenby Communal Area in the Pungwe basin has been destroyed during the past 20 years and maize is now grown down to the river's edge in contravention of the Natural Resources Streambank Regulations.

If the remnants of the Pungwe riverine forest is retained and rehabilitated, the river and its forest could serve as an important recreational resource to visitors and local residents, perhaps with introduced hatchery trout for anglers forming an important income source for the local authorities on a Campfire system

basis. The Pungwe River from its source to the Mozambique border is undoubtedly Zimbabwe's premier clear-water river and is without rival in the whole of Southern Africa.

d) Valley floor vegetation

The nature of the vegetation that occurs in various parts of the lowland valley floors of the Pungwe, Honde, and Nyamkwarara valleys is again dependent on the amount of rain that falls there, as well as on other factors such as slope and proximity to drainage lines. Although light shifting slash and burn cultivation has been practiced by the very few persons who lived in these valleys for perhaps close on a thousand years, it is only in the past 50 years that the population has increased exponentially. This has meant that very little now remains of the original vegetation because population pressures in this agriculturally desirable area have meant that even the steepest slopes have been stripped of their former mixed woodland cover and have been planted to various arable crops, principally maize. Much of the floor terrain in these valleys is potentially cultivatable as it varies from flat alluvial patches, gentle sloping ground, and to steep hillsides. The steeper areas (often on slopes of over 50%) are all hand cultivated.

d.i) Wettest subtropical – Mandeya and Mapokana ridges westwards to the base of the escarpment, mostly north of the Pungwe River. This was originally a dense woodland of various species of *Uapaca* (*U. kirkiana, U. nitida*, and *U. sansibarica*), *Parinari curatellifolia*, *Albizia adianthifolia*, and bamboo (*Oxytenanthera abysinnica*), most of which was possibly secondary growth on reverting shifting cultivation. Many creepers (*Dioscorea* spp. and *Mucuna poggei*) drape the trees, especially along drainage lines. There are a few very important, but small, open wetland areas along streams that have been the sole habitats for the very rare Marsh Tchagra Shrike (*Tchagra minuta*) and Flufftails (*Sarothrura*), but these are now rapidly being planted up to sugar cane and bananas, and a substantial part of the largest wetland was recently drowned by the creation of the new Nyawamba dam.

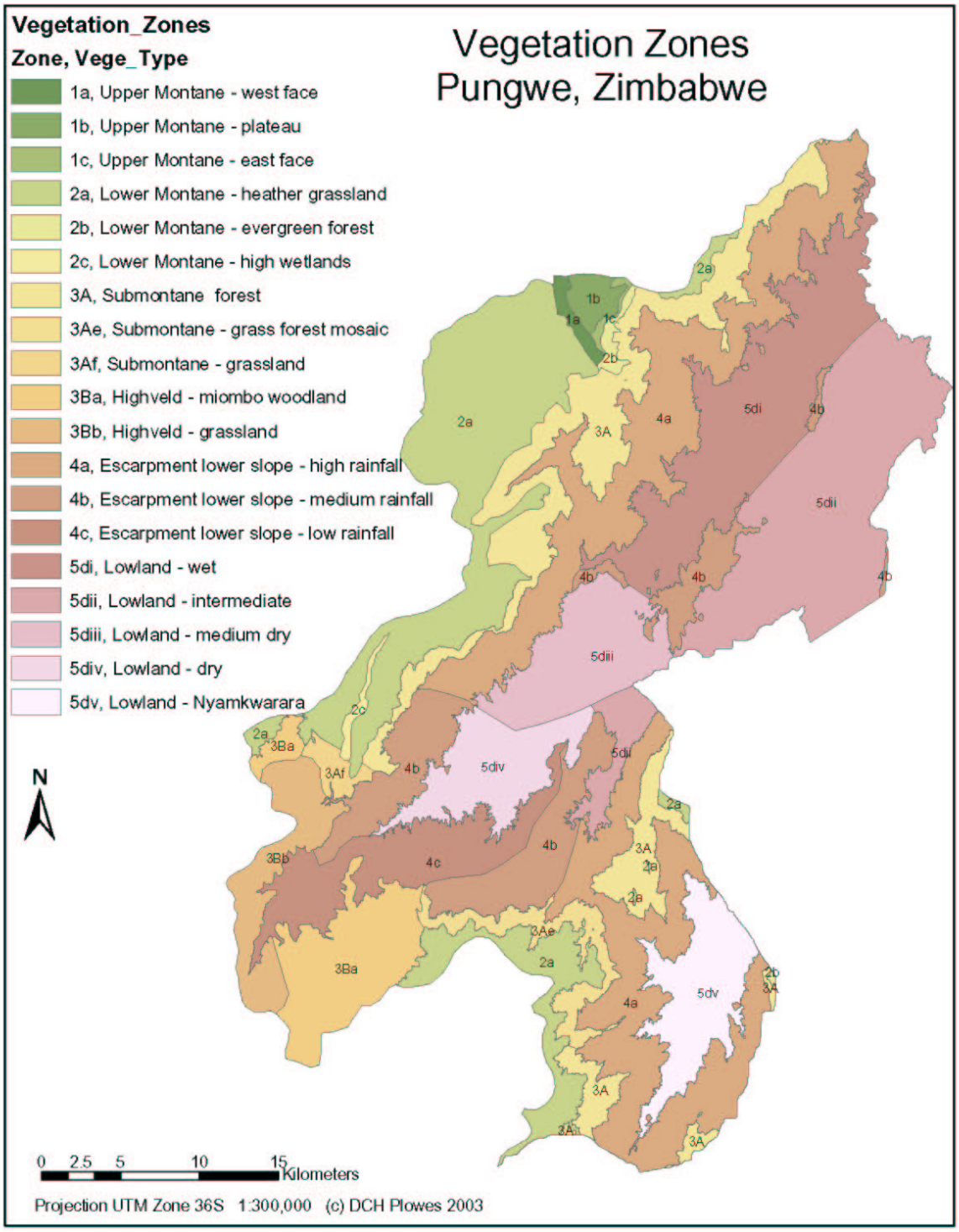
d.ii) Intermediate subtropical – Slightly drier areas east of Mandeya and Mapokana ridges to Mozambique border on north side of the Honde river, and also the Ngarura valley. Similar to the preceding, but with the absence of *Uapaca nitida* and *U. sansibarica* and less *Parinari*, and with the inclusion of *Brachystegia* spp. (probably *B. utilis* and/or *B. microphylla*).

d.iii) Drier valley plain – between the Ruda and the Honde rivers. Apart from a strip of tall *Breonadia salicina*, *Syzygium cordatum* and *Phoenix reclinata* along the Mtarazi River (now almost all gone) the relatively infertile red clay plain was a savanna grassland with *Hyparrhenia* spp., *Piliostigma thonningii*, and *Annona senegalensis* as the principal small trees and bushes. The main settlement and cultivation commenced from 1955 onwards.

d.iv) Driest valley floor – between the Honde River and the southern escarpment below Mt Ruinji. Miombo woodland (*Brachystegia, Julbernardia*, and *Uapaca*) on sandy loams.

d.v) The Nyamkwarara basin floor was very heavily utilised for staple crops until the persons who lived there were moved out by the Forestry Commission when they needed the land for planting Burmese Teak and pines. It is now a thick tangle of tall tropical grasses, Lantana, and Buffalo Bean (*Mucuna coriacea*). The teak grew well for the first five or six years, but has made almost no growth since. There appears to be more of the original vegetation on the east side of the Nyamkwarara River but there is no information about this. The water in the river is very red with mud from upstream gold panning.

The various types of forest in the Pungwe Valley have long been a Mecca for butterfly collectors because of the diversity and numbers of beautiful subtropical species that occur there, some of them comparatively rare and not known from elsewhere in Zimbabwe (e.g. *Acraea insignis* ssp. *gorongozae*). Likewise, they also harbour many very interesting subtropical birds, and they form a regular venue for organised ornithological safaris. The tall *Newtonia* forest at the Pungwe River Bridge and in similar forest patches are also home to Samango Monkeys (*Cercopithecus albogularis*) but no comprehensive survey has ever been done of the fauna that occurs there.


Vegetation_Zones
Zone, Vege_Type
1a, Upper Montane - west face
1b, Upper Montane - plateau
1c, Upper Montane - east face
2a, Lower Montane - heather grassland
2b, Lower Montane - evergreen forest
2c, Lower Montane - high wetlands
3A, Submontane forest
3Ae, Submontane - grass forest mosaic
3Af, Submontane - grassland
3Ba, Highveld - miombo woodland
3Bb, Highveld - grassland
4a, Escarpment lower slope - high rainfall
4b, Escarpment lower slope - medium rainfall
4c, Escarpment lower slope - low rainfall
5di, Lowland - wet
5dii, Lowland - intermediate
5diii, Lowland - medium dry
5div, Lowland - dry
5dv, Lowland - Nyamkwarara
Vegetation Zones
Pungwe, Zimbabwe
N
0 2.5 5 10 15
Kilometers
Projection UTM Zone 36S 1:300,000 (c) DCH Plowes 2003

ECOLOGICAL MANAGEMENT CONSIDERATIONS

Ecological sensitivity rating

To facilitate the formulation of an environmental management plan, it is necessary to assign ecological sensitivity ratings to the various vegetation communities based on the contained species, the state of the present situation (including the amount of disturbance and change already sustained), and the potential impacts that might arise from future project development or from other causes.

Zones, or plant communities within them, are usually rated from highly sensitive, sensitive, to moderately sensitive in order of importance, and also from their liability to be adversely affected by imposed extraneous factors.

Within the Zimbabwe portion of the Pungue Catchment, the following would appear to be the order of importance of the principal plant communities. This determination is made using the following criteria:

- The remaining size of the original ecosystem both within and outside the catchment
- The number of Red Data List or other rare species that it is known or is likely to contain
- The probable vulnerability of the ecosystem to disturbance
- The likelihood of further reduction of the ecosystem
- The aesthetic appeal of the ecosystem

Suggested order of importance based on the above criteria:

1 The Lowland riverine forests

2 The Tall Newtonia forests

3 The Lowland wetlands

4 The Escarpment Slope forests

5 The Sub-Montane grasslands

6 Aquatic ecosystems in the major and minor rivers

7 Sites that currently or formerly contained cycads

8 The Pungwe Gorge

9 The Highveld wetlands

Water abstraction

Any substantial reduction in the volume of water in the Pungwe River or its tributaries due to excessive abstraction might possibly pose a serious threat to the remnants of the very important and beautiful riverine forest there. At present, it is not known to what extent the existence of the riverine forest along the lower Pungwe is dependent on there being a high water table that would enable the river-bank trees to utilise water in the river. However, the trees that are immediately adjacent to the riverbanks would probably be able to survive lowered flows because their root systems would poossibly still encounter enough soil moisture during rainless periods, and at other times the rainfall would provide for their needs as in the past.

Agricultural Mismanagement

In high rainfall areas where rivers run through steep-sided valleys, groundwater from the surrounding higher ground would percolate down towards these rivers, supplying the moisture needs of tree roots en route. But if the higher ground loses its infiltration capacity due to agricultural mismanagement, then excess storm water would rapidly run off, lowering the quantity of water that the soil would previously have been able to capture and retain. Any storm-water that runs off will carry away any loose soil with it, and will also form gulleys.

It has to be appreciated that the soils in these subtropical valleys have developed for many millennia or even millions of years under an almost solid tree canopy and have been in equilibrium with the rainfall and the balance of the vegetation cover. Sudden exposure to the sun and air after clearing for crops destroys the organic matter in the topsoil through solar action and oxidization, and the contained roots and plant debris which initially bind and protect the soil from erosion are soon lost. Observations in the Pungwe Valley after mechanized clearing for tea and other crops showed that plant regeneration from roots and the rapid growth of weeds can ensure that no soil is lost, even from steep slopes, and that the soils there are still able to absorb

overnight falls of up to 800 mm of rain, provided that the plant debris is not totally destroyed. However, if the soil is deprived of even that amount of cover by burning and excessive cultivation and is left exposed to the hot sun for a long enough period, then it becomes capped and run-off is promoted with consequent sheet erosion.

This happened on the steep Madziwazira ridge (between the Pungwe and Ruda rivers) when the tall dense miombo woodland cover was all felled and burnt shortly after 1960 when the fertility of the soils on the Hauna/Gatsi plain was exhausted after a few years of cultivation. A crop of finger millet (*Eleusine coracana*) was grown on the ridge for two years using the fertility from the ashes, but the lands were thereafter also abandoned and became severely sheet-eroded. A similar state of affairs prevailed elsewhere in the Pungwe Valley. The water in the Pungwe River was no longer clean during flood episodes and but was extremely muddy, and flood peaks were now higher because the soils had lost much of their absorptive capacity and storm water was able to run off more rapidly and in greater quantity.

Soil erosion

The growing of annual crops on steep unprotected slopes, and the pernicious practice of burning all the weeds and old crop residues prior to hoeing, results in precious topsoil and the contained fertility being washed off the lands and into the streams and rivers with each heavy storm. The pools in the lower reaches of the Honde River near the Mahemasemike rock pinnacles that were deep enough to hold hippo and crocodiles prior to the 1950's became silted up with sand once the population in Mutasa North Communal Area began to build up and unprotected cultivation and overgrazing extended over the entire valley floor.

The Pungwe River was formerly permanently clear almost to the border, even during floods, because the dense vegetation growth prevented any form of erosion. The muddy flood waters that now occur on a regular basis appear to have caused the almost total demise of the Pungwe Chiselmouth (*Varicorhinus pungweensis*), a fish that was formerly abundant under the bridge to the tea estates. The dark green water-weed that coated the larger pebbles and small boulders there also seem to have disappeared, again probably due to being choked by silt during floods. It is almost certain that many riverine invertebrates will also have been impacted but no base-line data is available.

During the soil conservation drives carried out by agricultural staff in the 1960's and the 1970's, all arable lands in the higher rainfall areas were required to have 2 m wide grass strips at 1.5 m vertical intervals for soil

conservation purposes, in lieu of contour banks, the cropping of slopes steeper than 50% was prohibited, and the Streambank Protection Regulations were rigidly enforced; unfortunately however, this is no longer being done. Nevertheless, many persons have come to appreciate the benefit of protecting their arable lands and continue to do so on a voluntary basis.

The current spate of gold panning in the headwaters of the Nyamkwarara River over the border in Mozambique, and the resultant continuous pollution by red mud, must be having a very serious negative impact on all aquatic life in that river.

Deforestation

Deforestation due to fuel wood consumption, poles for building, or plant collection and tree mutilation for traditional medicinal use, is not currently evident on any significant scale within the National Park or on the tea and forestry estates, but there have been limited land invasion attempts. However, in the lower Pungwe Gorge opposite Buwu school in the Holdenby Communal Land, much of the remaining forest is currently being cleared on steep slopes, again often down to the high water mark level, to make way for agricultural activities. More people (often newcomers to the area) are taking up what vacant land still remains, right up to the Park boundary in the Pungwe Valley and possibly also within the Mtarazi Falls section. No replacement tree planting has been done in the catchment area to provide for future needs of the very rapidly expanding population of this fertile valley. Consequently, pressures on the remaining timber resources will escalate exponentially.

Veld fires

Uncontrolled or incorrectly planned fires can pose a threat to the floral integrity of the grassland communities on the plateau, but on the other hand, lack of fires can be even more serious by allowing undesirable shrubby vegetation to invade and suppress the remaining open grasslands. If fire has been excluded from a site for a long period of time and there is a big build-up of flammable material, the resultant fire is usually very destructive when the area eventually does get burned.

Fire is a necessary management tool for maintaining the grasslands, but its use has to be properly planned and supervised, and the fires should not be too frequent: a burn just before the rains about once in three years would probably be optimal, but there is no local research data to provide guidance. This needs to be a long-term research undertaking.

Many fires on the plateau originate in the adjacent Holdenby Communal Land in the course of traditional land clearing activities. Uncontrolled fires at the wrong time of year are particularly destructive because they can suppress regeneration of indigenous trees and alter the vegetation structure, whilst simultaneously causing the colonisation of many areas by exotic species, particularly *Acacia mearnsii* (wattle) along rivers. In addition, by destroying the layer of leaf litter, fires contribute to soil crusting, decrease in rain infiltration, and general desiccation of the vegetation.

The most frequently burnt areas are the Mtarazi Falls area and the eastern parts of the Nyanga National Park, and also all the Highveld farming areas. By contrast, the Pungwe Gorge and most of the lowlands usually remain unburnt

because the moist micro-climatic conditions that prevail there maintain green vegetation for much of the year. The cessation of regular controlled burning of the grasslands on the National Park plateau is leading to their invasion by pioneer shrubs such as *Hypericum revolutum* and the undesirable *Stoebe vulgaris*.

Alien vegetation

Certain commercially grown trees are posing an increasingly serious threat to the ecosystems in the upland areas by invading them with wind-born seeds and suppressing the indigenous vegetation. The two principal species that are involved are Black Wattle (*Acacia mearnsii*), and Mexican Pine (*Pinus patula*). Australian Blackwood (*Acacia melanoxylon*) is also becoming established at various sites within the Rhodes Nyanga National Park, but it tends to remain in small slowly expanding clusters. River-banks are especially susceptible to take-over by wattles.

BIBLIOGRAPHY

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

Biegel, H. M., & Mavi, S. (1972) - Revised Rhodesian Botanical Dictionary of Plant Names. Government Printer. Harare, Zimbabwe.

Burrows, J. E. (1990) - South African Ferns and Fern Alllies. Frandsen. Johannesburg

Clarke, Mary (1991) - Nyanga Flowers. Baobab Books. Harare, Zimbabwe.

Drummond, R. B. and Coates Palgrave K. (1973) - Trees of the Highveld. Longman Zimbabwe (Pvt) Ltd. Harare, Zimbabwe.

Fibeck, W. and Dare, M. (1994) - Terrestrial orchids in Zimbabwe : Excelsa No. 16 - Journal of Aloe, Cactus and Succulent Society of Zimbabwe. pp 47-71. Harare.

Jacobsen, W. B. G. - The Ferns and Fern Allies of Southern Africa. Butterworks. Durban, Republic of South Africa.

Lightfoot, C. (1975) - Common Veld Grasses of Rhodesia (Second Edition). Natural Resources Board, Harare, Zimbabwe.

Linley K. and Baker, B. (1972) - Flowers of the Veld. Longman. Harare, Zimbabwe. Zimbabwe.

Müller, T. (1994) - Classification and Conservation of Rainforests in Eastern Zimbabwe. Forestry Commission, Harare, Zimbabwe.

Palgrave, K. C. (2002) - Trees of Southern Africa (revised edition). C. Struik Publishers. Cape Town, Republic of South Africa.

Pardy, A. A. (1951-1956) - Notes on the Indigenous Trees and Shrubs of Southern Rhodesia. Rhodesian Agricultural Journal. Harare, Zimbabwe.

Plowes, D. C. H. and Drummond, R. B. (1990) - Wildflowers of Zimbabwe Longman Zimbabwe (Pvt) Ltd. Harare, Zimbabwe.

Russell Gibbs, G. E. (1991) - Grasses of Southern Africa. National Botanic Gardens. Pretoria, Republic of South Africa.

Tomlinson, R.W. (1973) – The Inyanga Area – an essay in regional biogeography. University of Rhodesia Series in Science: Occasional Paper 1. Harare, Zimbabwe

Van Oudtshoorn, F. P. (1992) - Guide to Grasses of South Africa. Briza Publications. Pretoria. Republic of South Africa.

West, O. (1974) - A Field Guide to the Aloes of Rhodesia. Longman Zimbabwe (Pvt) Ltd., Harare, Zimbabwe.

Common names of some Pungwe Basin plants

Botanical name	Common name
Acacia mearnsii	Black wattle
Albizia adianthifolia	Rough-bark flat-crown
Albizia gummifera	Smooth-bark flat-crown
Albizia schimperiana	Forest long-pod albizia
Annona senegalensis	Wild custard apple
Anthocleista grandiflora	Big-leaf tree
Brachystegia boehmii	Mupfuti; Mfuti
Brachystegia glaucescens	Mountain acacia
Brachystegia spiciformis	Msasa
Bridelia micrantha	Mitzeerie
Buddleia salviifolia	Butterfly bush
Carissa bispinosa	Y-thorned carrissa
Combretum molle	Velvet-leaved combretum
Cussonia arborea	Octopus cabbage-tree
Cussonia spicata	Common cabbage-tree
Cyathia dregei	Common tree fern
Dodonea viscosa	Sand olive; Mukonachando; MuTepipuma
Eragrostis acraea	Nyanga tussock grass
Erythrina abyssinica	Red-hot poker tree; Lucky-bean tree
Ensete ventricosum	Wild banana
Faurea saligna	Beechwood
Flacourtia indica	Flacourtia
Helichrysum mimetes	Curry flower
Hypericum revolutum	Curry bush
Julbernardia globiflora	Munondo; Mnondo
Lantana camara	Lantana
Macaranga capensis	Spiny macaranga
Macaranga mellifera	Mountain macaranga
Monotes engleri	Pink-fruited monotes
Mucuna coriacea	Buffalo bean
Newtonia buchananii	Forest newtonia
Parinari curatellifolia	Mobola plum; Muhatsha
Perotis patens	Bottle-brush grass
Phoenix reclinata	Wild date palm
Pinus patula Patula pine	Mexican pine
Protea welwitschii	Rusty velvet protea
Pteridium aquilinum	Bracken fern
Syzygium cordatum	Waterberry
Syzygium masukuense	Small-fruited waterberry
Trilepisium madagascariense	False fig
Uapaca kirkiana	Mahobohobo; Mujanje
Uapaca sansibarica	Lesser mahobohobo
Vangueria infausta	Wild medlar
Widdringtonia nodiflora	Mountain cedar

Specially Protected Species likely to be encountered in the Pungwe Catchment Area

BOTANICAL NAME	COMMON NAME	AREAS WHERE LIKELY TO BE ENCOUNTERED
Amaryllidaceae		
**Cyrtanthus rhodesianus*	Fire lily	Grasslands and at lip of Pungwe Falls
**Dierama formosum*	Hare bell	Damp grasslands rocky areas and stream banks
**D. inyangense*		
**Scadoxus pole - evansii*	Nyanga fireball	Forests on edge of escarpment from Mount Nyangani south towards Mtarazi Falls
Arecacea		
Borassus aethiopum (Raphia farinifera)	*Borassus palm (Raphia palm)*	On fertile soils in Holdenby C.A. (Not recorded in area, but might occur)
Asphodelaceae		
**Aloe inyangensis*		Nyanga National Park
**Aloe rhodesiana*		Nyanga National Park
** Aloe swynnertonii*		Nyanga National Park
**Aloe collina (ex A.saponaria)*		Nyanga National Park
Aloe myriacantha		Nyanga National Park
Aloe arborescens		Nyanga National Park
Kniphofia splendida	Golden Poker	Scarce in wet, swampy areas - NNP
Kniphofia linearifolia	Red-hot Poker	In bracken and rank grass - NNP
Colchicaceae		
Gloriosa superba	Flame lily	Forest margin among bracken and woodland on the highveld
Cyathaceae	The tree fern family	
Cyathea (all species)	The tree ferns	The Pungwe Gorge/Nyanga National Park
Orchidaceae		
All species of epiphytic or terrestrial orchids	Orchids	Miombo woodlands and forests, especially along rivers; + vleis, bogs and montane grasslands
Polypodiaceae		
Platycerium alcicorne	Staghorn fern	Pungwe Gorge forests & near Katiyo
Velloziaceae		
Xerophyta equisetoides	Brooms, brushes	On mountain slopes or rocky places
Zamiaceae		
**Encephalartos manikensis*	Cycads	Nyanga National Park/ Pungwe Gorge/Gorongo Mountain

*Species that are endemic to Eastern Highlands +Applies to terrestrial orchids only

List of names of plants collected and observed at Mtarazi Falls National Park, by T. Müller and H. M. Biegel, 22 - 25 October 1969

1. ABOVE FALLS (1700 - 1800m)

A. Woody Species

Rapanea melanophloeos (L.) Mez
Pittosporum viridiflorum Sims
Ekebergia capensis Sparrm.
Ilex mitis (L.) Radlk.
Apodytes dimidiata E. Mey.
Curtisia dentata (Burm. F.) C. A. Sm.

Macaranga capensis (Baill.) Sim
Maesa lanceolata Forssk.
Syzygium masukuense (Bak.) R. E. Fr.
Olea africana Mill.
Hypericum revolutum Vahl
Buddleia salviifolia (L.) Lam.

Myrica pilulifera Rendle
Philippia hexandra S. Moore
Cyathula cylindrica Moq.
Rubus rigidus Sm.
Rumex saggittatus Thunb.
Thalyctrum rhynchocarpum Dill. & Rich.
Peddiea africana Harv.
Tabernaemontana angolensis Stapf
Rhoicissus revoilii Planch

B. Herbs

Anthericum ? angulicaule Bak.
Dipcadi viride Moench
Unusual dun-brown flowers)
Buchnera tuberosa Skan.
Silene undulata Ait.
Geranium arabiqum Forssk.
Dissotis canescens (E. Mey. ex Grah. Triana)

Corrigiola drymarioides Bak. F.
Trachycalymna fimbriatum (H. Wim.) Bullock
Nidorella auriculata L.

Digitalis purpurea L.
Drymaria cordata (L.) Willd.
Impatiens sylvicola Burtt Davy
Silene burchellii Otth.
Vigna gazensis Bak. F.
Harveya randii Hiern
Peucedanum linderi Norman

Hydrocotyle manni Hook. F.
Satureia biflora (Buch. Ham. ex. Don) Briq.
Indigofera cecilii N. E. Br.

2. FIRST PLATEAU (half way down) (± 1200m)

Dracaena steudneri Engl.
Ensete ventricosum (Gmel.) Horan
Trema orientalis Blume

Albizia adianthifolia (Schumach) W.F. Wight
Cussonia spicata Thun. (one tree +/-40ft high, crown 50 ft diam)

Anthoceleista grandiflora Gilg
Phoenix reclinata Jacq.
Albizia gummifera (G. F. Gmel.) C. A. Sm. var. *gummifera*

Erythrina lysistemon Hutch.

Smilax kraussiana Meisn.

3. FOREST (foot Mtarazi Falls)

A. Herbs

Angraecopsis parviflora (Thou.) Schlechter
Polypodium polypodioides (L.) Hitchc.
Elatostemma orientale Engl.
Lycopodium ophoglossoides Lam.

. Woody Species

Phyllanthus discoides Muell. Arg.
Alangium chinense (Lour.) Harms (only Zimbabwean to date)
Maytenus chasei N. Robson
Pauridiantha symplocoides (S. Moore) Bremek.
Pseuderanthemum subviscosum (C.B.Cl.) Stapf

Englerophytum magalismontanum (Sond.)
Ficus ? thonningii B1. (large strangler, sterile)
Tricalysia myrtifolia S.Moore
Newtonia buchananii (Bak.) Gilbert & Boutique

Myrianthus holstii Engl.
Albizia gummifera (J. F. Gmel.) C.A. Sm. var. *gummifera*
Garcinia kingaensisi Engl.
Craibia brevicaudata (Vatke) Dunn subsp. *baptistarum* (Buttn.) Gillet
Catha edulis Forsk. (one tree estimated at 100ft plus)
Teclea nobilis Del.

Polyscias fulva (Hiern) Harms
Syzygium guineense (Wills) D.C. subsp. *afromontanum* White

Erythroxylum emarginatum Thonn.
Strombosia scheffleri Engl.
Gerrardina eylesiana Milne-Redh.
Trimeria rotundifolia (Hochst.) Gilg
Craterispermum schweinfurthii Hiern (common along river)
Scolopia stolzii Gilg
Sapium ellipticum (Hochst. ex Krauss) Pax (Common, some very large trees)
Pterocelastrus echinatus N. E. Br.
Trilepisium madagascariense (D.C.)
Chrysophyllum gorungosanum Engl.
Ixora narcissodora K. Schum.
Landolphia buchananii (Hall f.) Stapf (one very large liane)
Hippocratea africana (Wild.) Loes. var. *richardiana* (Cambess.) N. Robson
Tarenna pavettoides (Harv.) Sim
Drypetes gerrardii Hutch.
Khaya anthotheca (=K.nyasica)
Aningeria adolfi-fredericii (Engl.) Robyns & Gilb. (dominant above junction of 2 streams). Only Zimbabwean locality of date.
Cassipourea congolensis D.C.
Trichilia dregeana Sond.
Macaranga capensis (Baill.) Sim
Ochna holstii Engl.
Mimusops zeyheri Sond.
Oxyanthus speciosus D.C.
Celtis africanum Burm. F.
Dovyalis lucida Sim
Toddalia asiatica (L.) Lam.

4. BELOW EVERGREEN FOREST

Myrsine africana L. (a very short hairy form)
Chlorophytum blepharophyllum (Schweinf. ex Bak.)
Faurea forficuliflora Bak.
Dicoma kirkii Harv.

5. AREA ABOVE GATSHE SCHOOL

Becium homblei (De Wild) Duvigan & Plancke
Acalypha chirindica S. Moore
Solanum renschii Vatke

Aeschynomene nyassana Taub.

Brachystegia utilis Burtt Davy ex Hutch.

6. LOWER PUNGWE

A. Woody species

Newtonia buchananii
Albizia adianthifolia
Breonadia salicina
Ilex mitis
Teclea nobilis
Myrica pilulifera
Dodonea viscosa
Drypetes natalensis
Cremaspora triflora
Oxyanthus speciosus
Harungana madagascariensis
Vernonia umbratica

Albizia gummifera
Maranthes polyandra
Ficus sur
Mimusops zeyheri
Bridelia micrantha
Aida micrantha
Halleria lucida
Rutidea syringoides
Rhus chirindensis

Strychnos lucens
Polystichnum zambesiacum

B. Herbs

Selaginella crassiona

Cyperus giganteus

C. Ferns

Asplenium sandersonii

Appendix 2: Larger mammals (>5 kg) of Gorongosa National Park

Source Tinley (1997)

PRIMATES
- Chacma baboon
- Samango monkey
- Vervet monkey

PHOLIDOTE
- Pangolin

CARNIVORES
- Spotted hyaena
- Cheetah (extirpated c1950; 6 re-introduced in the north of GNP 1973)
- Leopard
- Lion
- Serval
- Wildcat
- Wild dog
- Side-striped jackal
- Clawless otter
- Spotted-necked otter
- Honey badger
- Civet

TUBULIDENTATA
- Antbear

HERBIVORES
- African elephant
- Zebra
- White rhinoceros (extirpated c1940; 6 reintroduced in the north of GNP 1970)
- Black rhinoceros
- Bushpig
- Warthog
- Hippopotamus
- Greater kudu
- Nyala
- Bushbuck
- Roan antelope (extirpated c1950-1970)
- Sable antelope
- Reedbuck
- Waterbuck
- Leichtenstein's hartebeest
- Tsessebe (extirpated c1950-1970 and may be extinct in Mozambique)
- Wildebeest
- Impala
- Red duiker
- Blue duiker
- Grey duiker
- Suni
- Oribi
- Klipspringer
- Steenbuck
- Sharp's grysbuck
- Cape buffalo

RODENTS
- Porcupine
- Greater cane rat

Appendix 3: A Selection of Birds recorded in Gorongosa National Park

Pelicans
- Pink-back pelican
- White pelican

Cranes
- Wattled crane
- Crested crane

Egrets, herons
- Grey heron
- Yellowbill egret
- Cattle egret

Storks
- Openbill
- Saddlebill
- Spoonbill
- Yellowbill stork

Darters, cormorants
- Darter
- Reed cormorant

Raptors
- Fish eagle

Guinea fowls
- Crested guineafowl

Doves and pigeons
- Rameron pigeon
- Delagorgues pigeon
- Red-eyed turtle
- Cape turtle dove
- Laughing dove
- Cinnamon dove
- Green pigeon

Turacos
- Green-crested turaco
- Purple-crested turaco
- Grey loerie

Mousebirds
- Speckled mousebird
- Red-faced mousebird

Hornbills
- Trumpeter hornbill
- Crested hornbill
- Grey hornbill
- Red-billed hornbill
- Yellow-bill hornbill
- Crowned hornbill

Barbets
- Black-collared barbet
- White-eared barbet
- Yellow-fronted tinker barbet
- Green-rumped tinker barbet
- Green tinker barbet

Crested barbet

Orioles

European golden oriole
African golden oriole
Black-headed oriole
Green-headed oriole

Bee-eaters

European bee-eater
Carmine bee-eater

Bulbuls

Black-eyed bulbul
Terrestrial bulbul
Yellow-streaked bulbul
Stripe-cheeked bulbul
Yellow-breasted bulbul
Sombre bulbul

Larks

Red-capped lark
Red-backed finch lark

Pipits

Richard's pipit.

Thrushes, chats, robins

Olive thrush
Gurney's thrush
Mocking chat
Natal robin
Heuglin's robin
Cape robin
Bearded robin
White-browed scrub robin
Starred robin
Sywnnerton's robin
Palm thrush
White-breasted alethe

Starlings

Wattled starling
Plum-coloured starling
Blue-eared glossy starling
Lesser blue-eared glossy starling
Black-bellied glossy starling
Red-wing starling

White-eyes

Yellow white-eye

Appendix 4: A proposed checklist for an EIA to assess impacts on Conservation Areas

NAME OF PCA.....
DATE.....
FINAL IMPACT SCORE.....

Impact Scores * (see note below)

+2 = Very beneficial impact	-1 = Adverse impact
+1 = Beneficial impact	-2 = Very adverse impact
O = Neutral impact	NA = Not applicable

A. DESCRIPTION

1. Conservation status of area

1.1 National park.....
1.2 National reserve.....
1.3 Other (specify).....
.....
.....

2. Type of intervention being assessed

2.1 Policy.....
.....
2.2 Legislation.....
.....
2.3 Administrative procedure.....
.....
2.4 Development project.....
.....
2.5 Industrial activity.....
.....
2.6 Agricultural practice.....
.....
2.7 Other (specify).....
.....
.....
.....
.....

IMPACTS (score as indicated above)

1. Ecological impacts

1.1 On sensitive habitats
- a. Wetlands.....
- b. Montane habitats.....
- c. Riverine habitats.....
- d. Arid or semi-arid areas.....
- e. Natural forests.....
- f. Other sensitive habitats (specify)
  .....
  .....
  .....

1.2 On encroachment on sensitive habitats.....
1.3 On biodiversity.....
1.4 On species composition.....
1.5 On species of special concern.....
- a. Endemic.....
- b. Threatened.....
- c. Rare.....
- d. Economically valuable.....
- e. Cultural significance.....

1.6 On reducing undesirable species.....
1.7 On fish resources.....
1.8 Other.....

2. Impacts on efficiency of wildlife management

2.1 On law enforcement.....
2.2 On staff morale.....
2.3 On hunting.....
2.4 On non-consumptive recreation.....
2.5 On protected area infrastructure.....
2.6 On public perceptions.....
2.7 On local community support.....
2.8 On implementing management plans.....

3. On sites or areas of special interest

3.1 Archaeological sites.....
3.2 Historical sites.....
3.3 Cultural sites.....
3.4 Geomorphological sites.....
3.5 Landscape aesthetics.....

4. Others (list as appropriate).....
.....
.....

Final impact scores

Impacts are scored on a scale of +2 to -2, the positive side of the scale representing beneficial impacts, and the negative side adverse impacts. A final impact score (FIS) for each intervention is reached by totalling individual parameter scores.

This apparently quantitative assessment of environmental impact has limitations. First, scoring against each parameter involves subjective judgements, which vary from person to person, although scoring by a team of assessors may smooth out subjectivity. Second, parameters do not carry equal weight, so that (for example) a score of -2 for impacts on a threatened species is not necessarily balanced by a score of +2 for staff morale. FISs give no more than a rough yardstick against which to make a qualitative comparison between the impacts of two or more interventions.