THE GOVERNMENT OF THE REPUBLIC OF MALAWI

MINISTRY OF AGRICULTURE IRRIGATION AND WATER DEVELOPMENT

SHIRE RIVER BASIN MANAGEMENT PROGRAMME (PHASE I) PROJECT

# CLIMATE RESILIENT LIVELIHOODS AND SUSTAINABLE NATURAL RESOURCE MANAGEMENT IN THE ELEPHANT MARSH, MALAWI

## Sub-Study 4:
## Biodiversity of the Elephant Marsh


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in Association with


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# PREFACE AND ACKNOWLEDGEMENTS

This study forms part of a larger study on the Elephant Marsh which also includes studies of the hydrodynamics, local communities and ecosystem services, in order to inform a management plan for the marshes and in order to prepare an application for Ramsar status as a wetland of international importance. The study team for the Biodiversity Study was as follows:

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|---|---|---|
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While each team member was focused on a particular area of biodiversity, the specialists helped one another in their fieldwork, collecting photographic records, recording ad hoc sightings and peer reviewing of the document. The team wishes to thank the following people for their assistance with the study:

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# EXECUTIVE SUMMARY

## Introduction

This study forms part of the larger project: “Climate resilient livelihoods and sustainable natural resources management in the Elephant Marsh, Malawi”. This project aims to generate a thorough understanding of the functional ecology of the Elephant Marsh, including its hydromorphology, biodiversity, ecosystem services, surrounding community livelihoods; and to investigate the implications of alternative possible management strategies through modelling. The assignment also assesses the feasibility of designating the Elephant Marsh as a wetland of international importance under the Ramsar Convention. If it meets the Ramsar criteria, the intention is to generate the information required to support an application for designation of the Elephant Marsh and develop an integrated management plan for the area that includes community-based management.

Wetland habitats, such as marshes, dambos (seasonal wetlands) and river floodplains provide a link between terrestrial and aquatic environments and support their own suite of flora and fauna. While many of the shallow and seasonal wetlands in Malawi have been completely converted to agriculture, the more permanent papyrus wetlands such as the Elephant Marsh can provide important refugia for wetland fauna. The Elephant Marsh lies within the floodplain of the Lower Shire River in southern Malawi. It covers an average area ranging from 500 $km^2$ in the dry season to 2 700 $km^2$ in the wet season. Its core area is a mosaic of rooted swamp vegetation (sudd), floating vegetation and open water with grassy margins. This is surrounded by seasonally-inundated grassy floodplains, which are in turn (originally) bordered by woodland.

While the biodiversity of certain ecosystems within Malawi such as Lake Malawi, Mt Mulanje and Lake Chilwa has been relatively well documented, the Elephant Marsh has received comparatively little attention, probably due to its inaccessibility.

The biodiversity component of the Elephant Marsh study involved specialised studies of several taxonomic groups: plants, aquatic invertebrates, dragonflies, butterflies, reptiles, amphibians, fish, birds and mammals. The specific objectives of these specialist studies were to:

- Describe the historical flora and fauna based on the literature and available data;
- Provide a quantitative and spatial description of each biotic group, including species distribution maps and population numbers or stocks and dynamics where possible;
- Determine the current threat status of all species, and provide an evidence base to support registration of the Elephant Marsh as a Ramsar site;
- Describe the overall ecology and the functional role of each group;
- Assess the present status of the component; and
- Describe the sensitivity of different biota to environmental changes highlighting groups or species particularly vulnerable to impacts of climate change.

Field work was carried out in the Elephant Marsh between June 2015 and March 2016 on four separate occasions; June/July 2015, November 2015, January 2016 and March 2016. Effort was made to survey the range of habitats present in the Elephant Marsh.

For the assessment of present status, the different components were rated on a scale of A to F in terms of their degree of resemblance to the estimated natural condition, in order to gauge overall biotic health of the system (Table I).

**Table I. Rating scale used to assess health of different components.**

| Ecological category | Description | % similar to natural |
|---|---|---|
| A | Unmodified. Still in a natural condition. | 91-100 |
| B | Slightly modified. A small change in natural habitats and biota has taken place but the ecosystem functions are essentially unchanged. | 81-90 |
| C | Moderately modified. Loss and change of natural habitat and biota has occurred, but the basic ecosystem functions are still predominantly unchanged. | 61-80 |
| D | Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. | 41-60 |
| E | Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive. | 21-40 |
| F | Critically / Extremely modified. The system has been critically modified with an almost complete loss of natural habitat and biota. In the worst instances, basic ecosystem functions have been destroyed and the changes are irreversible. | 0-20 |

## Vegetation

The vegetation of the Elephant Marsh was remotely mapped in order to guide sampling for both flora and faunal surveys. Of the six possible habitats types thought to occur, only four were expected to be well vegetated. These were lakes (= lagoons), floodplain, marsh and river banks. Sampling was conducted in these four habitat types in July 2015 at 18 sites accessible by car or boat.

In total, 70 species of reed, tree and shrub and 82 species of graminoids, groundcovers and aquatic plant species were recorded. None of these species are considered threated or of particular conservation interest.

Vegetation community composition was analysed using ANOSIM, cluster and SIMPER analyses. These analyses revealed that there was not much statistical difference in composition between cultivated and un-cultivated river banks and that the largest difference was between cultivated banks and lake habitats. While there was a high degree of overlap of species between all habitats, maize most commonly distinguished cultivated banks from other habitats, hippo grass *Vossia cuspidata* was most often found in river banks (regardless of being cultivated or not) and wire-leaf daba grass *Miscanthus junceus* was characteristic of floodplain habitats.

Cultivated banks were the most diverse; however this is mostly due to the wide range of disturbance-adapted annuals as well as the diversity of cultivated crops. In comparison, marsh habitats were not botanically diverse, being dominated mainly by the sedge *Cyperus papyrus* and the reed *Phragmites australis.*

The Elephant Marsh is not unique amongst wetlands within Malawi, with a few other large wetland marshes occurring nearby, such as the smaller Ndinde Marsh further downstream on the Shire and the much larger Lake Chilwa to the north-east.

The Elephant Marsh has undergone significant transformation in terms of the extent of cultivation taking place on the floodplains. Hydrologically there have also been some changes with the shifting of the main river channel, which have likely led to drying out (and subsequent transformation to agriculture) on the western side of the marsh.

Reeds and papyrus have been impacted very little because they are extremely resilient to being cleared and sprout rapidly and more densely in response to being cut. The biggest changes over the past century would have been in the loss of riparian woody vegetation along the main river banks. It is likely these large woody species would have been removed to allow for agriculture or used for building materials or fuel.

The overall condition of the marsh in terms of its vegetation was estimated to be in a D category, where the system is largely modified from is historical condition and/or associated with a large loss of habitat, biota and basic ecosystem functioning.

## Aquatic invertebrates

Aquatic macro-invertebrates are used worldwide as indicators of riverine condition because they respond to immediate and long term changes in catchment hydrology, geomorphology and physico-chemistry. The objective of the aquatic invertebrate part of this study was to determine the present day ecological status of the Elephant Marsh and some of the main tributaries in its immediate vicinity.

Field work was carried out in January 2016 and consisted of sampling at 26 sites in the Shire River, marsh and lakes as well as four sites in the westward flowing tributaries. For each site, the catchment and instream habitat was assessed, and *in situ* measurements of physical and chemical water quality variables were taken. Aquatic macro-invertebrates were sampled using the standard South African Scoring System, version 5 (SASS5) method and the dragonfly biotic index (DBI) was used where SASS5 was unsuitable.

The Shire River can be characterised as meandering in the northern sections and braided-meandering in the southern sections. In the northern area, the main river channel was sinuous, deep and relatively fast flowing, with eroded and vegetated banks, and presence of backwaters. The water was red-brown, and highly turbid with water clarity of only 2 cm. In the southern area, the river channel was wide, sinuous and deep, with fast flowing water in the mid-channel and slow-flowing backwaters with aquatic vegetation.  One of the lakes in the south-western marsh was characterised by clear stagnant water, with a high abundance of aquatic plant growth in the water column and along the edges of the water body. Water clarity in these south-western lake sites was >120 cm, with no visible flow.

The four sites on the inflowing tributaries were very similar to one another, and were characterised by highly turbid red-brown water, bank scouring, sediment movement and deposition, and the presence of cobble-boulder, gravel sand and vegetation biotopes. Bare stream banks were more common than vegetated banks.

A total of 77 taxa (excluding adult Odonata) were recorded in the study area, of which most were identified to genus or family, and some to species level. Taxonomic diversity was very low in sites located on the four tributaries. It is likely that that there are still refuge habitats for species in some of the upper tributaries in these systems. Species diversity in the Elephant Marsh increases downstream, as habitat heterogeneity increases.

Flow-sensitive species were recorded in very low numbers, while taxa with a preference for slow flows (0.3 to <0.1 m/s) dominated. Community composition shifted downstream in favour of taxa preferring slow to zero flows. This is attributed to the widening of the river channel and increase in slow-flowing habitats and presence of aquatic vegetation out of current. Taxa with a tolerance for high sedimentation were dominant. High sediment movement and deposition was evident, with the water being very turbid at most of the sampling locations. Taxa considered sensitive to pollution were well represented at the sites located in the northern sites, but decreased downstream while tolerant taxa increased. Within the lakes tolerant taxa dominated with only few sensitive taxa found. This was more related to the dissolved oxygen content of the clear water lake than anthropogenic pollutants. Large numbers of egg-shaped lanistes *Lanistes ovum* from the family Ampullariidae were recorded in the lake mainly where there were hornworts *Ceratophyllum demersum* and water lilies *Nymphaea lotus*. These appear to be the main food source for the abundant openbill storks.

Based on the limited abundance of flow- and habitat-sensitive taxa within the Elephant Marsh, and the high diversity and abundance of flow- and pollution-tolerant taxa, the present ecological state of this system more than likely falls within a moderately impaired class (lower C). The condition of the westward-flowing tributaries, were assessed to be severely modified (E), having little resemblance to their original state.  This suggests an overall rating of D.

## Dragonflies and damselflies

Odonata (dragonflies and damselflies) are the most conspicuous freshwater invertebrates. In addition to the general survey of aquatic invertebrates described above, a survey of the dragonfly and damselfly fauna was undertaken during March 2016. An effort was made to inspect as much of the study area as possible by boat in order to identify microhabitats that may harbour unusual species. Adults were observed and caught with a hand net during daylight.

Dragonfly and damselfly habitats were found to be very homogeneous and therefore results are only listed for the Nchalo area (mostly Nyala Park) and the Elephant Marsh proper (mostly the lagoons near Kaombe - a similar suite of species were found on the Nchalo side). Additional records were obtained from the general aquatic invertebrate survey in January 2016.

A total of 36 species were recorded. These represent 24% of the species currently known from Malawi. None are of conservation concern. All four species recorded previously in the area were found again.

Only 20 of the 36 species were observed in the Elephant Marsh proper. Fourteen additional species were found around the Nchalo plantation, especially in Nyala Park. Most of these also favour temporary water bodies, but often smaller and more sheltered. Two additional species were found in the inflowing tributaries in January 2016.

Of the 36 species recorded, only about 15 were seen more frequently, and six species made up the bulk of the abundant individuals encountered in the marshes. Diversity was thus relatively low and the group was dominated by a handful of species that respond well to the very dynamic environment.

The Odonata fauna was considered largely natural, although the *Pistia* specialist *C. kordofanicum* may have profited from the expansion of that weed. Thus the status of this group was rated as A-category (81-90% similar to natural). Other specialist species, like those of large rivers may be absent because good quality river habitat on the Shire has become rarer due to siltation and turbidity. *P. acaciae* was the only such specialist observed, but river species are also easily missed during a five-day survey.

## Butterflies

A butterfly survey was carried out in June 2015. Four areas were surveyed (North-east, North-west, South-east and South-west), with two sites sampled in each. Methods of sampling included the use of hand nets and examining food plants for larvae. In addition, traps baited with fermented banana were used at Nyasa Reserve on the Kaombe sugarcane estate in the south and the Nyala Park on the Nchalo sugarcane estate in the north.

A total of 62 species were recorded. Species richness was highest in the south-western sites and lowest in the south-eastern sites which had recently been extensively flooded. The additional presence of 37 species was suspected based on the observed occurrence of food plants on which these species depend. Up to 150 species (25% of Malawi's species) could potentially occur in the study area. However, in the heavily populated areas on the eastern side of the swamp, species numbers would be unlikely to be more than 40.

The only special find was a new race of *Colotis amata*. This was breeding exclusively on *Salvadoria persica* (toothbush/salt bush) on the lake edge. This plant will not be threatened by habitation as it offers shade for small ruminants, some food and is used by the population.

The degradation of the Elephant Marsh will have resulted in the disappearance of many species and where the highest population pressure occurs the species numbers will remain low. The marsh area around Kaombe (south-west) was assessed as Class C/D (80-40% similar to natural conditions), whereas the sites on the eastern side of the marsh were assessed as Class F (<20% natural), with an overall rating of E.

## Reptiles and amphibians

Amphibians are important components of wetland systems, particularly ephemeral systems in which fish are either excluded or of minor importance. In these habitats, they can be dominant predators of invertebrates, many of which may impact significantly on humans (e.g. as vectors of disease, such as mosquitoes and bilharzia snails) or their livestock and/or crops. Reptiles also form a significant component of vertebrate faunas in Africa. With the exception of land tortoises, all terrestrial reptiles are entirely or largely carnivorous. Reptiles therefore play an important role in nutrient cycling within ecosystems, and in population control of their prey items.

Field surveys were conducted for five days in July 2015 during the dry season and for five days in January 2016 during the wet season. Visual encounter methods were used. Diurnal methods involved active search of specific microhabitats, particularly beneath cover such as decaying logs or mats of vegetation. Nocturnal surveys for amphibians were undertaken in wetlands and surrounding woodland. In addition, funnel traps were deployed in the wet season within the Nyala Park Reserve.

A total of 25 amphibian species was recorded, representing 74% of the known amphibian fauna of the region. Five were previously unrecorded from the Lower Shire Valley, but known from adjacent areas. Eight species previously recorded from the Lower Shire Valley and Elephant Marsh were not encountered in this study. These species may have been inactive during the survey periods or overlooked.

In contrast, only 21 species of reptiles were recorded, representing 46% of the 58 reptile species known from the Lower Shire Valley. Seven other common species were reliably reported to occur in the region. Two species were added to the regional herpetofauna list during the current surveys and two species overlooked in the most recent surveys were reconfirmed.

None of the amphibian species known to occur are considering threatened or of conservation value. The existing amphibian fauna is considered to be similar to the original fauna before human impact, except for the possible reduction of tree frogs as a result of the loss of riparian trees. The reptile fauna is considered to be significantly impacted, with large snakes, particularly arboreal species, present in reduced numbers. Historical records show that two iconic reptiles of Malawi wetlands, the Zambezi Soft-Shell Terrapin *Cycloderma frenatum* and the Swamp Viper *Proatheris superciliaris*, both occurred in the Elephant Marsh region. These species were not recorded and are in danger of becoming regionally extinct, if not already so.

Large Nile crocodiles *Crocodylus niloticus* (>3 m) are still common in the Shire River and Elephant Marsh, but there are concerns for their continued survival. The main source of human-crocodile conflict and consequent hunting is the damage to gill nets set overnight for fishing. In addition, the crocodile farm in the area harvests eggs as well as a few adults for breeding stock.

## Fish

The lower Shire River has been ecologically disconnected from the middle and upper Shire River by a series of natural and man-made barriers. As a consequence, the fish fauna of the Lower Shire differs markedly from the areas upstream.

Fieldwork was undertaken in November 2015. Sampling was carried out throughout the Elephant Marsh using a combination of catch-based and fisheries-independent methods. Sampling sites represented all four main habitat types found in the Elephant Marsh and were selected while in the field, working within the limitations of accessibility. Sampling was also undertaken in the Majete Wildlife Reserve to the north and in mountain streams to the east of the Elephant Marsh.

Fresh catches were inspected at 15 landing sites throughout the study area. These observations were compared with the species list generated through fisheries-independent surveys. Fisheries-independent surveys involved sampling a range of sites with a variety of fishing gears, including scoop nets, seine nets and electric fishing gear.

A total of 52 fish species from 17 families were recorded (n=43) or strongly expected to be resident (n=9) in the study area based on previous surveys. The fish fauna comprised a few large and several small family groups, the largest being minnows and barbs (5 genera and 18 species of Cyprinidae), followed by cichlids (4 genera and 6 species of Cichlidae); mormyrids (4 species of 4 genera); air-breathing catfishes (3 *Clarias* spp., 1 *Heterobranchus* sp.); mochokid catfishes, African tetras and Poeciliidae (each with 3 species); and a further 10 families represented by two or a single species.

One species, the sanjika *Opsaridium microcephalum*, has been assessed by the IUCN Red List as Vulnerable, and two species, the African mottled eel *Anguilla bengalensis labiate* and the Mozambique tilapia *Oreochromis mossambicus*, are considered to be Near Threatened. Whilst not considered threatened by the IUCN Red List, the widespread lungfish *Protopterus annectens* is restricted to seasonal pools, which are susceptible to land use change and drainage, and so may be at risk locally.

Poor management of the catchment poses a risk to fish biota through increasing sedimentation in the rivers. This can lead to the deterioration of many habitats important to numerous fish species, and ultimately decrease the abundance of sensitive species or even result in local extinctions.

Fishing pressure is reasonably high in some parts of the Elephant Marsh (conversely, some areas are probably fished at low intensity due to difficulty in access) and the abundance of some species may be locally suppressed in these areas. Small-scale fisheries occur throughout the Elephant Marsh, using four main gear types: gill nets, long lines, cast nets, and fish traps. The majority of the catch is made up of the sharptooth catfish *Clarias gariepinus* and the Mozambique tilapia, and fishers retained almost all individuals.

The loss of seasonal floodplain habitat to cultivation throughout the marsh is likely to have reduced the extent of available breeding and feeding habitat for many species, and therefore their overall abundance in the Elephant Marsh. However, this change has probably not led to the local extinction of any species, at least in recent decades, as considerable seasonal floodplain habitat still exists.

Overall, the current fish biodiversity is probably significantly modified from pristine conditions with losses to biodiversity; however the system still appears functional. These impacts are due to fishing pressure and major changes in riverine habitat over the past 100 years or more.

## Birds

The avifauna survey was carried out over seven days in March 2016. This involved 1) creating a checklist of the avifauna of the Elephant Marsh area, 2) aerial surveys of the Elephant Marsh using a microlight, 3) boat based surveys of the accessible areas of the upper marsh, 4) land based surveys of an accessible wetland in the upper marsh, 5) surveys of the marsh lagoons of the lower Elephant Marsh, 6) counts at waterbird communal roosting sites and 7) the analysis of previous data collected as part of the African Waterbird Census.

A total of 199 bird species were recorded in the Elephant Marsh area, of which 68 species were waterbirds. The various counting methods proved to be complementary, with microlight counts being most efficient, but other methods proving useful for filling the gaps, for example for numbers of small species. Based on all the different counts, and accounting for various forms of bias and potential double counting as far as possible, a total of 20 238 birds were estimated to occur in the areas counted. The most abundant species were openbill stork and white-faced tree duck (both over

3000), and African jacana, common squacco heron and cattle egret, which all numbered over 1 500. This is likely a severe underestimate for the entire marsh, as a large proportion of the wetland was not covered by any of the counts.

The Ramsar Convention considers a wetland to be of 'international importance' if it regularly supports over 20 000 waterbirds. The grand total of all waterbirds counted at Elephant Marsh during the March 2016 survey exceeded this threshold. This applied even with the figures for African fish eagle, African marsh harrier, osprey, and malachite and pied kingfishers, species not classified as waterbirds by Ramsar, were excluded. It should also be noted that the roost counts for cattle egret, black-crowned night heron and glossy ibis were higher than those recorded during the waterbird counts. When the grand total was adjusted by removing the figures for the aquatic raptors and kingfishers and substituting the maximum counts for the roosting egrets, herons and ibises, it increased to 21 825.

A wetland can also be classified as 'a wetland of international importance' under the Ramsar Convention if it regularly supports 1% or more of a delineated population of a waterbird species. The March 2016 counts revealed totals in excess of the 1% thresholds for the following species: openbill stork (counted - 3991, 1% threshold – 3900), whiskered tern (counted – 246, 1% threshold – 85), and African skimmer (counted 113, 1% threshold – 100). The African Waterbird Census counts also corroborated this finding with counts exceeding the 1% threshold for whiskered tern, African skimmers and common pratincoles. Given that the counts by AWC and this study are all undercounts to at least some degree, it is also likely that the actual numbers of common squacco heron, black egret, and long-toed plover also exceed the 1% Ramsar threshold.

In conclusion, there is clear evidence that Elephant Marsh qualifies as a 'wetland of international importance' based on its waterbird populations both relative to the total number of waterbirds present (>20 000) and relative to certain waterbird species exceeding the relevant 1% population thresholds.

Eight of the waterbird species that have been recorded at Elephant Marsh or at least in the lower Shire River area are globally threatened species. These are: Madagascar Squacco Heron, Lesser Flamingo, Wattled Crane, Southern Crowned Crane, Great Snipe, Bar-Tailed Godwit, Curlew Sandpiper and African Skimmer. However for only one of these species, African Skimmer, does the Elephant Marsh appear to be a significant locality. Otherwise, the value of Elephant Marsh lies in its supporting a wide diversity of waterbirds and, more especially, particularly high numbers of aquatic birds.

In its reference state, Elephant Marsh would still have had natural marsh in the extensive areas currently under cultivation. The reference state would also have supported far more tree cover in the marsh itself and the entire area surrounding the marsh would have comprised tall woodland. Particularly important would have been the absence of human fishing activities and human disturbance factors. The current state of the waterbird avifauna was estimated to be 61-89% similar to natural (Class B or C). A small number of species have disappeared from the system or at least been greatly reduced in numbers. A larger portion of species have likely undergone some level of lesser decrease and an equally large portion has likely not decreased at all.

## Mammals

Early-Malawi is estimated to have supported more than 200 mammal species, with the Elephant Marsh supporting more than 140. Mammal numbers are expected to have dropped systematically with the increase of humans in the Elephant Marsh area, with highest diversity most probably remaining in pockets further away from the larger human settlements.

A mammal survey was undertaken for five days in March 2016. This involved: 1) sampling small mammals through four trap transects; 2) surveying bats using a trap and a bat detector; 3) looking for signs of mammals; 4) using camera traps; and 5) conducting informal interviews with local people about the presence of mammals. Due to constraints on access and safety of traps, small mammal trapping, bat trapping and the use of the camera traps were mostly confined to the more secure Nyala Park.

Transect trap success was low and only yielded the opportunist and generalist Natal multimammate mouse *Mastomys coucha*. Three bat species were caught in the harp traps – the Mauritian tomb bat *Taphozous mauritianus*, little free-tailed bat *Chaerephon pumilus* and Angola free-tailed bat *Mops condylurus,* and a fourth was observed - the yellow-winged bat *Lavia frons*. Nine bat species were identified from echolocation recordings.

A total of 52 mammal species were directly or indirectly observed in the Elephant Marsh study area. The highest number occurred in the two conservation areas surveyed, 45 in Nyala Park and 36 in Nyasa Sanctuary. In comparison, only 13 were observed in the Nchalo Area, 11 in the Kaombe area and only three on the Shire River and islands. It should be noted that although the amount of time spent in each of these habitats was not even, these numbers are likely indicative of the pattern of distribution of the mammalian fauna, where fewer species exist outside of conservation areas.

At least 108 species are expected to still occur in the study area, with 37 more species being "uncertain/presence not impossible". Thirty-five percent of these 145 species are bats, 26% are rodents, 15% are carnivores, and 8% are bovids (all of which are considered as "uncertain" as most have probably been hunted out).

Due to hunting by the local population, many of the mammal species are expected to occur in very low numbers (if at all). A large percentage (42%) of the 37 "uncertain" species can be considered as relatively easy to catch and highly sought after as food or for traditional purpose (e.g. aardvark, Cape porcupine, squirrels, ground pangolin and almost all bovids), and were found only in the protected areas Nyala Park and or Nyasa Wildlife Sanctuary. Eight (6% of) species that occurred here historically have been lost from the Elephant Marsh outside the two protected areas, and a further 19 (13%) are listed as presence "uncertain". Seven of the eight lost species are currently listed by the IUCN as threatened species, and so are three of the 37 "uncertain" species. Only one threatened species (hippopotamus, listed as Vulnerable) remains present at the Elephant Marsh, outside of the protected areas. However, the hippopotamus population was estimated to be less than 100, far fewer than the more than 1 000 individuals that are expected to have occurred under more natural conditions. Eight additional species + three "uncertain" species are currently listed by CITES.

With such a number of species already lost and the presence of more species uncertain (even though they should occur in the specific habitats in the specific area) we can argue that the ecosystem is already under stress, and could probably be classified as being in an E class.

## Overall status of the Elephant Marsh

The Elephant Marsh has been significantly altered from its natural state in many different ways over the past 150 years. The surrounding population of people has increased dramatically and the natural vegetation remaining in the catchment has dwindled.

The increasing population pressure has led to the removal of most of the woody riparian vegetation along the banks of the Shire as well as the large scale conversion of floodplain vegetation to agriculture. The abundance of reptile, amphibian and mammal faunas that would normally have inhabited the area on a permanent or seasonal basis, has been curtailed by loss of habitat to cultivation, loss of prey species, or through direct hunting and persecution by people. Most large animal species have been extirpated from the area, which is likely to have altered the functioning of the system to some degree. Waterbird fauna seems to be in a reasonable state, but fish populations are likely to be significantly depressed due to fishing.

In spite of the fact that the Elephant Marsh system has been significantly altered and has lost much of its original wetland and floodplain area to agricultural use and human settlement, it still contains large enough areas of functional marshes and floodplain habitats to support significant biodiversity and ecosystem services. The populations in these areas have been impacted on by direct harvesting, however, as much of the study area is accessible by foot or mokoro. Only a small proportion of the original Marsh area remains relatively unimpacted. Nevertheless, wetlands and their fauna are naturally fairly resilient. The Elephant Marsh is therefore considered to be in a D category in terms of its overall health (Table II).

**Table II. Health rating for different biotic groups**

| Group | Description | Rating |
|---|---|---|
| Vegetation | Largely modified | D |
| Aquatic Invertebrates | Moderately modified. | D |
| Odonata | Slightly modified. | B |
| Butterflies | Seriously modified | E |
| Reptiles & Amphibians | Moderately to largely modified. | C/D |
| Fish | Moderately to largely modified. | C/D |
| Birds | Slightly to moderately modified | B/C |
| Mammals | Seriously modified | E |
| **Overall** | **Largely modified** | **D** |

## *Main threats to the biodiversity of the Elephant Marsh*

The main overall threat to the Elephant Marsh is the growing human population, not only directly surrounding the marsh but within the catchment and Malawi as a whole. This population pressure has resulted in increased water abstraction, conversion of natural vegetation, sediment input, movement and deposition, as well as biodiversity losses. The resultant high turbidity reduces the productivity of the littoral zone, smothers substrates, and reduces food source availability and fish visibility (which can affect hunting for many species).

Another of the main threats to the Elephant Marsh are the unknown implications of the proposed abstractions from the Shire River and the possible upgrades to increase the capacity of the Kapichira Falls Hydroelectric Power Station. Marsh vegetation will be impacted by reduced flow, as drying will reduce the ability of marsh plants to resprout and therefore to persist and will also make it easier to clear marsh areas for cultivation. The encroaching human population will put further pressure on the system as extraction of natural resources, and access to previously inaccessible areas will become possible. The frequency of fires during dry periods in the marsh and surrounding areas has likely increased with burgeoning numbers of people and their ongoing encroachment into the marsh. This burning process also facilitates drying out of papyrus habitat, which further enables the encroachment of people and cultivation into the marsh. These fires also have a negative effect on reptilian, amphibian and small mammal populations.

Ongoing felling and removal of the remaining large trees bordering the Elephant Marsh will further impact groups of fauna that rely on these fringing habitats such as waterbirds that rely on such areas for roosting and breeding as well as mammal species that use these thicker habitats as refugia from the surrounding cultivated and disturbed matrix.

The large commercial sugar-cane estates on the edge of the marsh also impact the wetland through habitat modification on its edge, water extraction for irrigation erosion and potentially the runoff of agro-chemicals (pesticides and fertilizers) into the wetland, raising the possibility of contamination and eutrophication from these sources. While floodplain vegetation can be somewhat resilient to subsistence agriculture, commercial agriculture tends to transform soils and more effectively remove indigenous species through mechanical clearing, ploughing of fields and the use of herbicides and pesticides. This decreases the likelihood that unassisted natural recovery may take place where this occurs.

Fishing pressure throughout most of the marsh is particularly intense, however, given the size of the marsh the fish populations seem to be in a reasonable state currently. This fishing activity, however, negatively impacts waterbirds through competition for fish resources, direct disturbance from human fishermen, and drowning and entanglement in fishing nets, especially gill nets, and fishing tackle.

Invasive alien floating weed species such as water hyacinth *Eichhornia crassipes*, water lettuce *Pistia stratiotes* and water fern *Azolla filliculoides* are very abundant across the Elephant Marsh, sometimes forming large mats which almost completely cover smaller lakes. Predominance of these weeds can clog waterways, change drainage patterns and lead to low oxygen levels in the water which can be detrimental for aquatic invertebrates and fish species. In addition these alien invasive plant species could have profound ecological impacts on the wetland avifauna by reducing habitat for certain species.

The original mammalian megafauna that once inhabited the marsh, including elephant, hippo and buffalo, have now been mostly lost. These megafauna would have played an ecological engineering role in the functioning of the marsh through nutrient cycling and maintaining marsh channels. All large species, other than the hippopotamus, no longer exist outside of conservation areas. As such, the continued persecution and removal of hippopotamus from the system poses a threat to the continued functioning of the system.

Of one the largest threats to fauna within the Elephant Marsh is hunting by local inhabitants. Poaching and illegal harvesting of fish, reptiles, mammals and birds also take place inside the protected areas associated with the Elephant Marsh. If the combined pressures of population and poverty continue to increase, these problems will probably be exacerbated.

## Recommendations

*1. Apply for Ramsar status*

One of the primary recommendations of this study is that an application to have Elephant Marsh designated as 'a wetland of international importance' under the Ramsar Convention should be formally pursued. This would focus critical national and international attention on this significant and valuable wetland in order to ensure that it is managed in a sustainable manner meeting both human and biodiversity needs.

*2. Secure environmental flow requirements*

In order to ensure that future projects and developments upstream of the Elephant Marsh do not disrupt the functioning of the system and any newly designated conservation area, an Environmental Flow Assessment should be conducted for the Shire River and the Elephant Marsh (as well as other large marshes downstream such as the Ndinde Marsh). Such an assessment would determine the minimum flows and water quality needed to sustain a healthy and functioning marsh.

*3. Afford high level of protection to priority areas*

Despite its potential conservation importance, human pressures on the Elephant Marsh are extremely high, and restoration of the Elephant Marsh would be an unrealistic goal. Instead it is recommended that an effort is made to protect and improve the health of remaining marsh area, particularly the lower half of the Marsh. The protected area needs to be of sufficient extent to conserve viable populations, and to maintain the supply of ecosystem services. Currently, the most naturally-functioning and least disturbed lakes and marsh are found in the centre and southern portions of the Elephant Marsh, largely due to their being permanently inundated and difficult to access (*mokoros* can only cover relatively short distances in one day). These less disturbed habitats are presently supporting source populations of species that sustain the livelihoods of the local villagers so the social benefits of preventing degradation of these habitats would be significant. This part of the Marsh ideally needs to be declared as a no-go area in order to maintain natural ecosystems, but other factors may need to be taken into account in order to develop a successful strategy.

*4. Create conservation corridors*

There are a number of conservation areas in and around the Elephant Marsh, but there are no safe corridors that connect them. In one instance, between the Nyala Park and Lengwe National Park, a river forms a natural corridor – but it is not safe for animals to move/migrate. This issue needs to be addressed, especially if populations of larger mammals are to be maintained within the Elephant Marsh area. In addition, the lateral connectivity of alluvial rivers is considered key to the ecological integrity of the Elephant Marsh (Ward & Stanford 1995). Better management of the tributaries of the Shire and their inclusion in the creation of conservation corridors would likely have a positive effect on aquatic biodiversity in the region in general.

*5. Improve management of surrounding impacted habitats*

Further destruction of the functional elements of the Marsh, particularly the use of dry season fires to promote access to the extensive papyrus beds, should be banned. In addition, soil conservation practices should be encouraged and efforts to halt deforestation should be implemented. These goals are extremely difficult to achieve, but progress is being made in the development of effective policy measures. Effort should be made to design effective measures based on evidence from experiences elsewhere.

*6. Improve management of utilised populations*

In order to improve management of harvested populations including crocodiles, fisheries, woody resources, etc., it is recommended that a programme of environmental education is devised for government officials and key stakeholders involved in fisheries and natural resources management that is specific to the management of the resources of the Elephant Marsh and its surroundings. This would cover the biology and ecology of the species involved, monitoring methods, management objectives and management responses.

*7. Research and monitoring*

Regular monitoring is needed in order to determine the rate and scale of environmental change in the Elephant Marsh. A suitable monitoring programme should be designed that is simple enough to ensure its continued implementation. It should focus on gathering information on relevant indicators of known environmental impacts, including changes in flow, sedimentation, and fishing, as well as expected emerging threats, such as pollution. This should also include systematic monitoring of key biodiversity indicators and species of concern.

*8. Change means of problem animal control*

In order to try and conserve the hippo population of the Elephant Marsh there needs to be a more effective protocol on culling for human-wildlife conflict mitigation (rather than shooting an animal whenever a resident makes a complaint. This would need to be done in conjunction with close monitoring the population as well as seeking to establish (or enlarge e.g. the Nyala Park and Nyasa Wildlife Sanctuary) so that they include a part of the major river(s) and have a safe (patrolled) entrance for hippos. Additionally, making use of known effective methods (e.g. knee high wire/cables) to keep the hippos from specific areas can lessen the degree of human-wildlife conflict.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| AASPT | Adjusted average score per taxon |
| ANOSIM | Analysis of similarity |
| ANOVA | Analysis of variance |
| DoF | Department of fisheries |
| DBI | Dragonfly biotic index |
| EC | Electrical conductivity |
| FFG | Functional feeding group |
| LIFE | Lotic invertebrate index for flow evaluation |
| MDS | Multidimensional scaling ordination |
| ODA | Odonata database of Africa |
| PSI | Pollution sensitivity index |
| SASS5 | South African scoring system, version 5 |
| SIMPER | Similarity of percentages analysis |
| SRBMP | Shire River Basin Management Programme |
| VEGRAI | Vegetation Response and Assessment Index |

# 1 INTRODUCTION

## 1.1 Background

The Government of Malawi received a credit and a grant from the International Development Agency (IDA – World Bank Group) to finance the implementation of the Shire River Basin Management Program (Phase I) Project. The overall Program Development Objective of the Shire River Basin Management Program (SRBMP) is to increase sustainable social, economic and environmental benefits by effectively and collaboratively planning, developing and managing the Shire River Basin's natural resources.

The larger project under which this study falls is the 'Climate resilient livelihoods and sustainable natural resources management in the Elephant Marsh, Malawi' study. This project aims to generate a thorough understanding of the functional ecology of the Elephant Marsh incorporating hydromorphology, ecosystem services, biodiversity, and livelihoods; and model past, present, and future possible management strategies. The assignment also assesses the feasibility for designating the marsh as a community-managed protected area and as a wetland of international importance under the Ramsar convention using information from the surveys to assess whether the Elephant Marsh meet the Ramsar Criteria. If it does the intention is to generate the information required to support an application for designation of the Elephant Marsh and develop an integrated management plan for the Marshes that supports community-based management.

This biodiversity report forms one of the sub-sections of this overall project. The objectives of this component are to:

- Describe the historical flora and fauna based on literature/available data;
- Provide a quantitative and spatial description of current flora and fauna (birds, mammals, reptiles, amphibians, fish, dragonflies and butterflies), including species distribution maps and population dynamics where possible;
- Determine the current threat status of all species, and provide an evidence base to support registration of the Elephant Marsh as a Ramsar site;
- Describe the overall ecology and the functional role of each group, and;
- Describe the sensitivity of different biota to environmental changes highlighting groups/species particularly vulnerable to impacts of climate change.

Collection and analysis of the presence and abundance of plant and animal species is important for three main reasons: (1) to determine the biodiversity conservation priorities of the area, (2) to determine ecosystem health, and (3) to assess the populations, status and value of species that contribute to household livelihoods. The first aspect of the biodiversity assessment will provide important information on endemic species, vulnerable, endangered, or critically endangered species or threatened ecological communities. This will be important for establishing that the Elephant Marsh meets the Ramsar criteria and providing the evidence in support of designation. The second and third aspects will be incorporated into the models that will be used to assess the resilience and value of the Elephant Marsh. This component will have important links to the livelihood and ecosystem valuation components.

## 1.2 National and regional context

Malawi is a small land locked country of which almost a quarter is covered by freshwater lakes and wetlands. While the majority of the remaining land would once have been predominately covered miombo woodland with patches of evergreen forest or shrubland, there has been substantial conversion to agriculture. Satellite data from 1973, 1992 and 2010 indicate that the percentage of forest cover across Malawi decreased from 38% to 23% to 18% respectively (LTS International Ltd 2013). During the same period the area of cropland has increased from 33% in 1973, 49% in 1992 and then 54% in 2010. This rapid land transformation has placed increasing pressure on Malawi's ecosystems and remaining natural areas. Much of the remaining natural areas in Malawi are confined to national parks, forest reserves and wildlife sanctuaries and reserves. Malawi currently has 87 forest reserves, five national parks, four wildlife reserves and three nature sanctuaries covering 21% of Malawi's land area (Government of Malawi 2015). While this percentage is one of the highest on the continent, not all of these types of parks and reserves provide adequate protection to the flora and fauna species which inhabit them. High surrounding population pressure as well as lack of resources for patrolling/enforcing boundaries have led to many of these areas being heavily poached and/or deforested (Government of Malawi 2014).

Malawi is home to some unique and diverse biodiversity, partially due to its diversity of available habitats. Malawi ranges in elevation from 3 000 m a.m.s.l. on the tops of mountains like Mt. Mulanje to below 100 m a.m.s.l. in the lower reaches of the Shire River Valley. The levels of endemism and number of threatened species are quite high in groups like plants and fish (Table 1) but lower for other groups. The predominant habitats across Malawi include Afromontane forest, miombo woodland, freshwater lakes and wetlands. Additional habitats types include mopane woodland, Zambezian woodlands and deciduous woodland and thicket.

At the higher altitudes remnants of Afromontane forest can be found which, due to their isolation, have been found to have many unique and endemic species such as the flora, herpetofauna and Odonata of Mt Mulanje (Strugnell 2002, Dijkstra 2004, Branch & Cunningham 2006).

**Table 1. Number of known species, levels of endemism and threat status of flora and fauna in Malawi. Threat status is based on IUCN Red List. * indicated groups where is it likely the number of threatened species if higher due to few assessments being conducted or lack of data. Source: Fifth report to CBD, Government of Malawi (2014). Note that some of these figures have been assessed by Specialists in this report and are updated in following sections.**

| Species | Total Species | Endemic | Threatened |
|---|---|---|---|
| Plants | >6 000 | 122 | 248* |
| Mammals | 192 | Not known | 8 |
| Birds | 630 | 1 | 16 |
| Amphibians | 83 | 6 | 12 |
| Reptiles | 145 | 8 | 8 |
| Fish | >1 000 | 950 | Not known |
| Insects | 8 770 | Not known | 8* |
| Microorganisms | 700 | Not known | Not known |

The lower-lying miombo woodland covers most of the untransformed areas left in Malawi. Miombo woodland ranges extensively throughout southern and central Africa (Malmer 2007). Many of the species found in these habitats within Malawi are thus also found elsewhere in neighbouring countries. Miombo woodland has, throughout its range, had a long history of human transformation through small-scale shifting cultivation using fire (Malmer 2007). In recent times, this habitat type has been the focus of most of the transformation to more permanent cultivation (LTS International Ltd 2013).

Freshwater habitats like Lake Malawi are home to a diversity of freshwater endemic fish with over 800 species found in the Lake alone; granting it the highest levels of fish diversity worldwide (Wildlife and Environment Society of Malawi 2005). The fish diversity in Malawi is dominated by cichlid fishes which have shown extensive speciation and adaptive radiation throughout African freshwater lake systems (Turner *et al.* 2001).

Wetland habitats, such as the marshes surrounding Lake Chilwa, dambos and river floodplains, provide a habitat that links terrestrial and aquatic environments and as such support their own suite of flora and fauna quite distinct from the habitats described above. While much of the shallow and seasonal wetlands such as floodplains and dambos have been completely converted to agriculture (LTS International 2013), more permanent papyrus wetlands can provide important refugia for faunal species such as fish (Mnaya *et al.* 2006). Because floodplains and occasionally flooded areas surrounding the core of wetlands provide fertile agricultural land, these areas are often cultivated up to the edge of the permanently inundated zone. This increases pressure on the wetlands. Lake Chilwa wetland has been granted Ramsar status due to its large and diverse populations of resident and migratory waterbirds (Ramsar 2015).

Malawi lies within the eastern part of the Zambezi River basin, forming almost 8% of the basin's area. The Shire River is the main outflow of Lake Malawi and flows approximately 410 km to where it drains into the Zambezi River in Mozambique (Banda, 2004), see Figure 1.

## 1.3 The Elephant Marsh

The Elephant Marsh (S14°25'–17°50' and E35°15'–35°15') lies within the floodplains of the Lower Shire River and straddles the two administrative districts of Chikwawa and Nsanje (see Figure 2). It's area varies between approximately 2 700 km$^2$ in the wet season to 500 km$^2$ in the dry season (average 600 km$^2$; Kosamu 2014). The marsh currently extends from the south-eastern part of Illovo sugar estate at Chikwawa to the rail bridge and berm at Chiromo.

The Elephant Marsh is a mosaic of rooted swamp vegetation (sudd), floating vegetation and open water with grassy margins (Figure 3). Marsh habitats are interspersed with islands with saline soils and palm trees (Kosamu 2014). The northern margins are classified as 'semi-permanent' marshland inundated only during high water flows whereas the south features lakes with islands and floating mats of vegetation.

Flows into the marsh via the Ruo River can exceed those of the Shire River during floods, causing backflow into the marsh, sometimes with substantial flood damage and loss of life as was the case in 1950, 1991, 2001, 2011, 2012, and 2015 (Kosamu 2014).

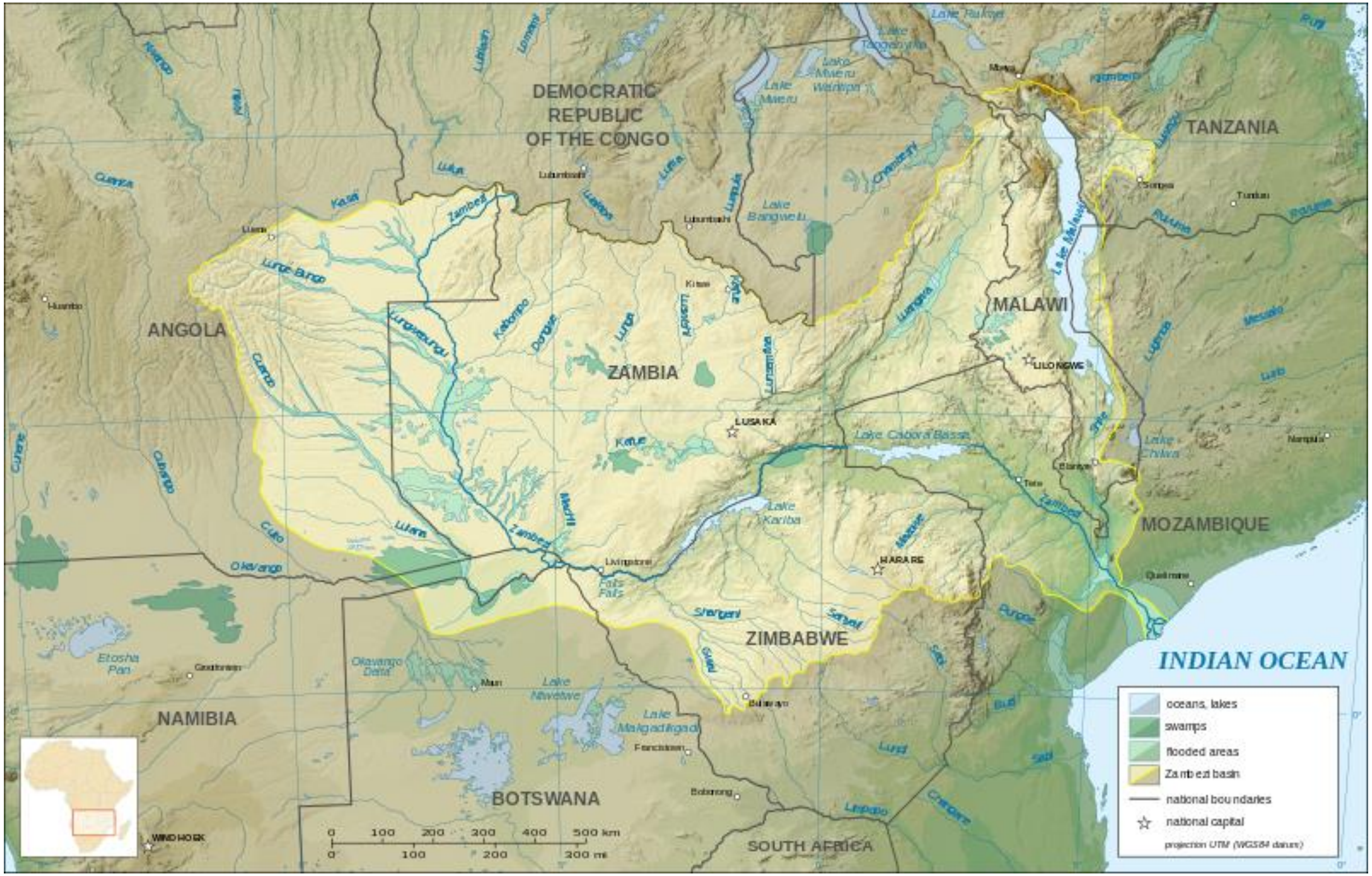


**Figure 1. The Zambezi River Basin.**

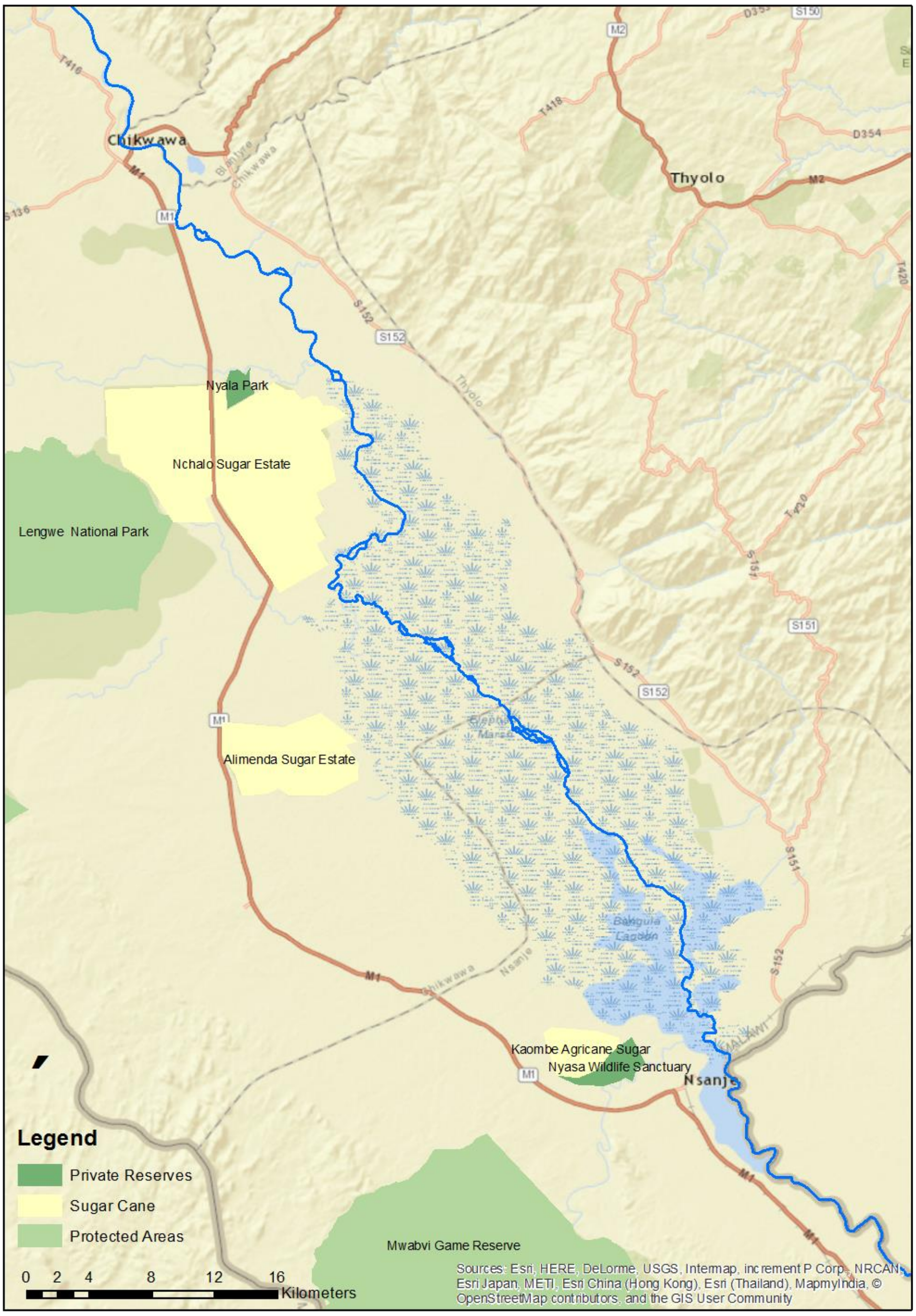


**Figure 2. Lower Shire valley showing the Elephant Marsh and nearby conservation areas and sugar cane estates.**

Named the Elephant Marsh by David Livingstone, this vast wetland area was once home to large numbers of game including herds of elephant, buffalo and antelope (Mitchell 1953, Jawali 2015). The Elephant Marsh was one of the first two Games Reserves gazetted in Malawi in 1897, along with Lake Shirwa [Chilwa] Reserve. The Elephant Marsh Reserve was then subsequently deproclaimed in 1911 (Jawali 2015). Increasing human pressure and expanding agriculture have led to dramatic declines in remaining natural areas and wildlife numbers. The marsh now plays an important role in supporting livelihoods and helping local communities to cope with considerable climate variability.

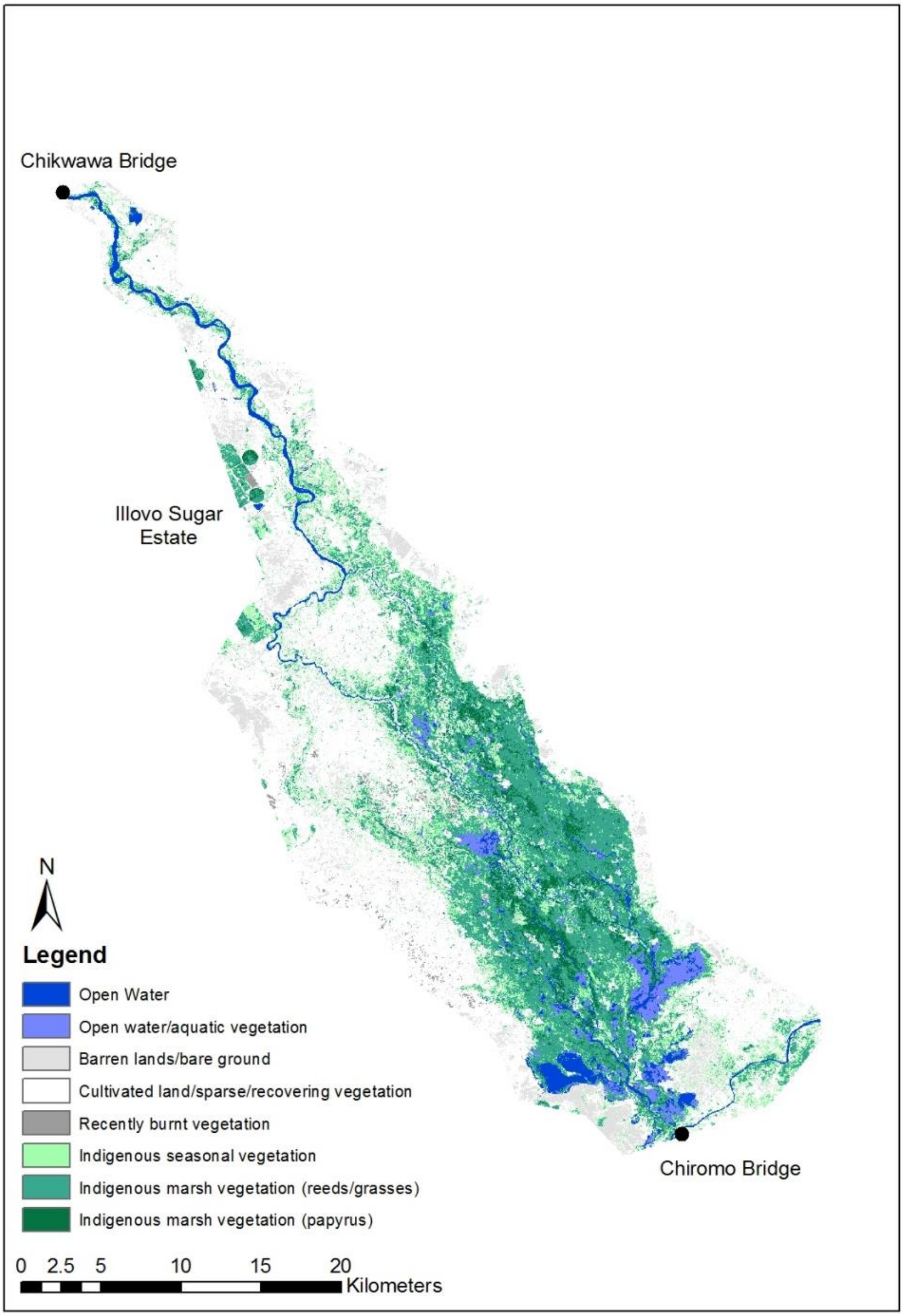


**Figure 3. Extent of indigenous vegetation in the Elephant Marsh (this study)**

While the biodiversity of certain ecosystems within Malawi such as Lake Malawi, Mt. Mulanje and Lake Chilwa have been relatively well documented, the Elephant Marsh has received comparatively little attention, probably because of its inaccessibility.

## 1.4 Objectives

The main aims of this sub-component were (1) to determine the conservation importance of the system, (2) to determine ecosystem health, and (3) to assess the stocks, status and value of species that contribute to household livelihoods. The first aspect of the assessment aimed to provide important information on endemic species, vulnerable, endangered, or critically endangered species or threatened ecological communities. This will be important for establishing that the Elephant Marsh meets the Ramsar criteria and providing the evidence in support of designation. The second and third aspects will be incorporated into the models that will be used to assess the resilience and value of the Elephant Marsh. This component will have important links to the livelihood and valuation components of the broader study.

## 1.5 Overall approach

The biodiversity component involved specialised studies of several taxonomic groups: plants, aquatic invertebrates, dragonflies, butterflies, reptiles, amphibians, fish, birds and mammals. The specific objectives of these studies were to:

- Describe the historical flora and fauna based on the literature and available data;
- Provide a quantitative and spatial description of each biotic group, including species distribution maps and population numbers or stocks and dynamics where possible;
- Determine the current threat status of all species, and provide an evidence base to support registration of the Elephant Marsh as a Ramsar site;
- Describe the overall ecology and the functional role of each group;
- Assess the overall level of health of the component; and
- Describe the sensitivity of different biota to environmental changes highlighting groups or species particularly vulnerable to impacts of climate change.

Field work was carried out between June 2015 and March 2016. Specialists decided on the best timing for sampling their particular group of interest. Trips generally consisted of five days in the field and were planned to coincide with the low water dry season, rising water early wet season or peak water levels in the late wet season. Late onset of summer rains, led to the postponing of the early rainy season trip. The timing of the trips was as follows:

- June/July 2015 (early dry season): reptiles, amphibians and vegetation
- November 2015 (late dry season): fish
- January 2016 (early rainy season): reptiles, amphibians and aquatic invertebrates
- March 2016 (late rainy season): mammals, birds and dragonflies

Efforts were made to survey the range of available habitats. The most effective way to sample each biotic group in a short space of time differed. It should be noted that it did not make sense to try and have the same study sites for the different biotic groups (for example fish and reptiles occupy different habitats), so the sampling locations differed for each specialist study. The details of sampling methods for each of the target groups are provided in the relevant chapters. In all cases, sampling sites were reached by boat, or in some cases, by off-road vehicle.

In addition to ground and boat sampling, the study area was also observed from the air using a microlight. The microlight was flown for approximately six hours during three early morning sessions in March 2016, and was used to photograph the habitats from the air as well as to count hippopotami and birds. The photographs were not geotagged, but were assigned locations on a grid based on the time of each shot and the time recorded on a GPS track that was recorded simultaneously. These aerial photographs provided a very different perspective than was gained from a boat or vehicle, and were shared with the whole team to enrich their understanding of the marsh.

The different components were rated on a scale of A to F in terms of their degree of resemblance to the estimated natural condition, in order to gauge overall biotic health of the system according to the following scale from A-F (Table 2), where D is generally considered the minimum acceptable level of health.

**Table 2. Categories of ecological condition (Kleynhans 1996).**

| Ecological category | Description | % similar to natural |
|---|---|---|
| A | Unmodified. Still in a natural condition. | 91-100 |
| B | Slightly modified. A small change in natural habitats and biota has taken place but the ecosystem functions are essentially unchanged. | 81-90 |
| C | Moderately modified. Loss and change of natural habitat and biota has occurred, but the basic ecosystem functions are still predominantly unchanged. | 61-80 |
| D | Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. | 41-60 |
| E | Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive. | 21-40 |
| F | Critically / Extremely modified. The system has been critically modified with an almost complete loss of natural habitat and biota. In the worst instances, basic ecosystem functions have been destroyed and the changes are irreversible. | 0-20 |

## 1.6 Limitations

While the January trip did coincide with some rainfall, the season was considered a failed rainy season and no subsequent major flooding took place. This meant that water levels were also relatively low during the March trip.

The study was carried out with a very limited budget, originally designed to accommodate two biodiversity specialists in the field during three site visits and using an airboat that was to be supplied at no cost to the field researchers. Through their generosity and dedication to science, instead we were fortunate to have on our team some of the top experts in the region for several sub-disciplines. However, we were nevertheless limited in resources for transportation. The airboat that had been ordered by the SRBMP and which was meant to be available for the specialists arrived late (in November 2015 rather than April 2015) and then broke down within weeks of arrival, and could not be used. This severely limited access into the marsh, as boats with outboard motors often got tangled in aquatic weeds and there were limited launch sites, due to low water levels. While motor boats could navigate the main channel fairly easily, they were often not able to get into the shallow side channels. Local canoes (*mokoros*) were better at accessing shallower areas, but were slow, which restricted the distance travelled in one day. The microlight provided a better opportunity for observing habitats, waterbirds and hippopotami. However, because of budget limitations, flying time was very limited.

Sampling was also constrained by the large flood in January 2015 that washed away many of the bridges on the eastern bank of the Marsh. This, combined with the fact that Ruo River changed its course enters upstream of the Chiromo rail bridge and berm, meant some areas of the marsh were impassable.

**Figure 4. View of Elephant Marsh from microlight**

# 2 VEGETATION

## 2.1 Introduction

The objective of the vegetation study was to identify and describe vegetation communities of the Elephant Marsh. To assist this process:

- a list of wetland plant species and communities expected in the Elephant Marsh, were compiled from the scientific literature on wetlands of the Zambezi River basin;
- a map of the Marsh was prepared from Google Earth images to guide data collection. The map distinguished cultivated and non-cultivated land, marsh (papyrus sudd), lakes, river channels, roads and main towns.

Field data collection took place in July 2015. Data collected from the Marsh were combined with the regional species list to develop a plant species list and used to describe the dominant vegetation communities and the ecological condition of the vegetation.

### 2.1.1 Summary of available information

There is a dearth of literature and relatively few data for the vegetation of the Elephant Marsh, although a recent environmental and social impact assessment (ESIA; SMEC 2013) did provide species lists for five sites located near Chiromo Bridge at the south end of the marsh.

This paucity of data necessitated using literature from similar wetlands and rivers to describe the vegetation communities and species expected to occur there. The sources of information used are provided in Table 3. The pertinent information contained in these is summarised for vegetation biodiversity, wetland types and plant species in the sections that follow.

**Table 3. Sources used to prepare plant community descriptions and species lists.**

| Source | Location | Data/information | Authors |
|---|---|---|---|
| The vegetation of Lake Chilwa. | Lake Chilwa, Zomba, Malawi | Descriptions of marsh and floodplain habitats and plant species lists. | Howard-Williams & Walker 1974 |
| The macrophyte vegetation of Bangula Lagoon. | Elephant Marsh, Bangula | Soil chemistry, air mean air temperature and rainfall, water quality, aquatic and terrestrial plant species lists. | Proctor 1980 |
| The ecology and management of African wetlands. | Africa | Ecological functioning of African wetlands and life history characteristics of typical plants species. | Denny 1985 |
| Aquatic macrophytes of the Shire River. | Shire River basin | Plant species list for the Shire River basin. | Blackmore *et al.* 1988 |
| A directory of African wetlands. | Elephant Marsh | General descriptions of habitat, flora and fauna, human use and impacts. | Hughes & Hughes 1992 |
| Biodiversity of the Zambezi Basin Wetlands. | Zambezi River basin | Descriptions of the Zambezi River basin and biodiversity data. | Timberlake 2000a |
| Biodiversity of the Zambezi Basin Wetlands: Phase II. | Zambezi River basin | Plant species list for the Shire River and general wetland vegetation community descriptions. | Timberlake 2000b |
| Kamazu Barrage ESIA. | Lake Malawi, Shire River | Plant species lists for five locations at the southern end of the Elephant Marsh. | SMEC 2013 |

### 2.1.2 Zambezi River Basin plant diversity

There are eight broad vegetation types in the Zambezi River Basin. Of these, swamps, pans and lakes/lagoons (including floodplains) represent only 7% of the total cover (Table 4). Southern African swamps, pans and lakes are not particularly rich in endemics, as most species have evolved generalist life history characteristics in response to the dynamic nature of the aquatic ecosystems they inhabit. As a result, aquatic and riparian species are generally widespread across the African continent, with the exception of some species found in the floodplains of the upper Zambezi River Basin, a focal point of much evolution and species radiation (Timberlake 2000a).

Timberlake (2000b) reviewed the literature on wetland plants of the Zambezi River Basin and compiled a list of 736 species (*ca.* 2% of all plant species in the basin). None of these are red-data or threatened species. Seventy-seven percent of these are widely distributed in eastern and southern Africa and some have an Afrotropical, pantropical[1] or worldwide distribution (Table 4). Furthermore, for obligate wetland plants, the proportion of widely-distributed species rises to 86%. Timberlake (2000b) was unable to distinguish between upper-, middle- and lower Zambezi River Basin plant communities, despite this distinction being clear for wetland fauna (dragonflies and mayflies, fish, freshwater molluscs and reptiles).

**Table 4. Broad vegetation types of the Zambezi River basin (Timberlake 2000a, derived from White 1983).**

| Biome | Vegetation group | % area of Zambezi River Basin |
|---|---|---|
| Zambezian - wet | Miombo woodland | 49 |
| | Woodland/dry forest/grassland mosaic | 19 |
| | Dry evergreen forest | 3 |
| | Swamps and pans | 4 |
| | Lakes | 3 |
| Zambezian - dry | Mopane woodland | 12 |
| | Acacia/mixed woodland | 7 |
| Montane | Montane forest/grassland | 2 |
| Coastal | Coastal forest/woodland/grassland mosaic | 1 |

### 2.1.3 Shire River wetland types

There are numerous classifications of African aquatic and riparian plant communities (e.g., Blackmore *et al.* 1988, Denny 1985, Howard-Williams & Walker 1974, Hughes & Hughes 1992, Proctor 1980, SMEC 2013, Smith 1976 & 1991, Timberlake 2000b), each of which uses slightly different categories of wetland habitat. Smith (1976, 1991; cited in Timberlake 2000b) was used in this project as it is a relatively simple classification of wetland habitats and of these six were expected to occur in the Elephant Marsh (lake, marsh, floodplain, river bank, sandbank and channel; Table 5), although they tend to be indistinct.

The Elephant Marsh is a floodplain wetland that responds to the water and sediment regimes of the Shire River. Floodplain wetlands experience short duration flooding at an annual or longer term frequency. The volume, timing and character of flow (and sediment transport) through the river, and the geological character and history of the landscape, create site specific fluctuations in surface and

[1] Pantropical: distributed in the tropics of all continents.

groundwater flow. This varied fluvial geomorphology of the marsh influences plant growth characteristics and results in extremely variable vegetation ranging from narrow riparian areas along anastomosing channels, dominated by grasses and sedges or trees and shrubs, to permanently inundated reed marshes and lakes, and broad seasonally inundated floodplains and pans.

As with other floodplain wetlands, sedimentation causes constant change in wetland structure as channels aggrade and scour in response to changes in flow and sediment regimes.

**Table 5. Six wetland habitats expected to occur in the Elephant Marsh.**

| Wetland habitat | Definition | Description |
|---|---|---|
| Lakes | Bodies of barely flowing water of varied depth. | Shallow lakes with clear water normally contain submerged and floating-leaved aquatic plants throughout whereas deeper or turbid lakes normally contain emergent plants at the shoreline only. |
| Marshes | Marshes may be perennial or seasonally inundated areas with slow flow that are well vegetated. | Permanently-inundated marshes are inhabited by megagraminoids, such as *Cyperus papyrus, Phragmites australis* and *Vossia cuspidata.* Seasonally-inundated marshes are inhabited by plant species able to survive drier conditions as seed or underground storage organs, such as *Miscanthus junceus* and *Phragmites australis.* |
| Floodplains | Seasonally inundated grasslands that border perennial rivers. | Floodplains are normally dominated by graminoids (grasses, rushes, sedges and reeds) as the higher water table and poor drainage preclude most trees and shrubs. |
| River banks | The terrain alongside a river variously inundated by floods of different magnitude within and between years. | River banks are inhabited by a dense layer of shrubs and trees adapted to regular inundation by floods. These so-called riparian areas are characterised by zones of different plant assemblages adapted to different flood magnitudes and inundation frequencies. |
| Sandbanks | Temporary lateral or mid-channel bars comprised of alluvium (river washed sands). | Typically sandbanks are poor in organic matter and therefore populated by ‘weeds’ with short life cycles. In some cases, reeds and pioneering riparian trees may colonise sandbanks, increasing their stability and permanence. |
| Channels | Perennial rivers or distributaries through swamps | Perennial rivers tend to flow faster than swamp distributaries and therefore flow velocity, with corresponding rooting strength, are important determinants of the plant species found. |

The Elephant Marsh is dominated by marsh and floodplain habitat and as such the vegetation comprises graminoids (grasses, sedges, rushes and reeds). A large proportion of the floodplains and some of the marsh periphery are cultivated, which means that the dominant undisturbed habitat is marsh. The numerous lakes (referred to as lagoons by the locals), which may only be connected to the river channels in the wet season, are dominated by floating and submerged aquatic plants and sustain large populations of water fowl and fish. Most river banks have been cleared for cultivation and so there are virtually no trees and shrubs present in the riparian area. Islands of elevated land, other than river banks, are small in extent and mainly peripheral. Sandbanks occur in the Shire River channel and generally are poorly vegetated, as are the strongly flowing river channels.

### 2.1.4 Lower Shire River plant species

Blackmore *et al.* (1988) collated a list of wetland plant species for the lower Shire River (Table 6). This list was expanded upon by Timberlake (2000b) who described each species' distribution and growth form.

**Table 6. Wetland plant species of the Lower Shire River, their life forms and distribution.**

| Group | Family | Species | Life form | Distribution |
|---|---|---|---|---|
| Pteridophyta | Adiantaceae | *Azolla filliculoides!!* | Submerged | Afrotropical |
| | Salviniaceae | *Salvinia hastata* | Submerged | Afrotropical |
| | Thelpteridaceae | *Cyclosorus interruptus* | Emergent | Afrotropical |
| | | *Thelypteris confluens* | Emergent | Afrotropical |
| Monocotyledons | Araceae | *Pistia stratiotes!!* | Submerged | Afrotropical |
| | Arecaceae | *Borassus aethiopum* | Tree | Afrotropical |
| | | *Hyphaene petersiana* | Tree | Southern Africa |
| | | *Phoenix reclinata* | Tree | Afrotropical |
| | Commelinaceae | *Commelina diffusa* | Emergent | Afrotropical |
| | Cyperaceae (sedges) | *Carex cognata* | Emergent | Afrotropical |
| | | *Cyperus alopecuroides* | Emergent | Afrotropical |
| | | *Cyperus alternifolius* | Emergent | Afrotropical |
| | | *Cyperus articulatus* | Emergent | Afrotropical |
| | | *Cyperus aterrimus* | Emergent | ? |
| | | *Cyperus difformis* | Emergent | Afrotropical |
| | | *Cyperus digitatus* | Emergent | Afrotropical |
| | | *Cyperus distans* | Emergent | Afrotropical |
| | | *Cyperus dives* | Emergent | Afrotropical |
| | | *Cyperus esculentus* | Emergent | ? |
| | | *Cyperus exaltatus* | Emergent | ? |
| | | *Cyperus imbricatus* | Emergent | Afrotropical |
| | | *Cyperus longus* | Emergent | ?Southern Africa |
| | | *Cyperus papyrus* | Emergent | Afrotropical |
| | | *Cyperus pectinatus* | Emergent | Afrotropical |
| | | *Cyperus rotundus* | Emergent | Afrotropical |
| | | *Cyperus zollingeri* | Emergent | ? |
| | | *Fuirena ciliaris* | Emergent | Afrotropical |
| | | *Kyllinga cartilagniea* | Emergent | ? |
| | | *Mariscus dubius* | Emergent | ? |
| | | *Oxycaryum cubense* | Emergent | Afrotropical |
| | | *Pycreus mundii* | Emergent | Afrotropical |
| | Hydrocharitaceae | *Ottelia scabra* | Submerged | ? |
| | Lemnaceae | *Lemna aequinoctialis* | Submerged | Afrotropical |
| | | *Lemna minor* | Submerged | Afrotropical |
| | | *Spirodela polyrrhiza* | Submerged | Afrotropical |
| | | *Wolffia arrhiza* | Submerged | Afrotropical |
| | | *Wolffiella welwitschii* | Submerged | Afrotropical |
| | Najadaceae | *Najas horrida* | Submerged | Southern Africa |
| | | *Najas marina* | Submerged | Afrotropical |
| | Poaceae (grasses) | *Chloris gayana* | Emergent | Afrotropical |
| | | *Cynodon dactylon* | Emergent | Afrotropical |
| | | *Dactyloctenium giganteum* | Emergent | Afrotropical |
| | | *Digitaria debilis* | Emergent | Afrotropical |
| | | *Echinochloa haploclada* | Emergent | Afrotropical |
| | | *Echinochloa jubata* | Emergent | Southern Africa |
| | | *Echinochloa pyramidalis* | Emergent | Afrotropical |
| | | *Echinochloa stagnina* | Emergent | Afrotropical |
| | | *Eragrostis aethiopica* | Emergent | Afrotropical |
| | | *Eragrostis arenicola* | Emergent | Afrotropical |
| | | *Eragrostis ciliaris* | Emergent | Afrotropical |
| | | *Eragrostis cylindrifolia* | Emergent | Afrotropical |

| Group | Family | Species | Life form | Distribution |
|---|---|---|---|---|
| | | *Eragrostis inamoena* | Emergent | Afrotropical |
| | | *Eragrostis tremula* | Emergent | Afrotropical |
| | | *Eriochloa macclounii* | Emergent | Southern Africa |
| | | *Hemarthria altissima* | Emergent | Afrotropical |
| | | *Hyparrhenia filipendula* | Emergent | Afrotropical |
| | | *Ischaemum afrum* | Emergent | Afrotropical |
| | | *Leersia hexandra* | Emergent | Afrotropical |
| | | *Leptocarydion vulpiastrum* | Emergent | Afrotropical |
| | | *Leptochloa fusca* | Emergent | Afrotropical |
| | | *Leptochloa uniflora* | Emergent | Afrotropical |
| | | *Panicum coloratum* | Emergent | Afrotropical |
| | | *Panicum graniflorum* | Emergent | Southern Africa |
| | | *Panicum maximum* | Emergent | Afrotropical |
| | | *Panicum subalbidum* | Emergent | Afrotropical |
| | | *Panicum scrobiculatum* | Emergent | Afrotropical |
| | | *Pennisetum purpureum* | Emergent | Afrotropical |
| | | *Phragmites australis* | Emergent | Afrotropical |
| | | *Phragmites mauritianus* | Emergent | Afrotropical |
| | | *Sacciolepis africana* | Emergent | Afrotropical |
| | | *Setaria incrassata* | Emergent | Afrotropical |
| | | *Sorghum versicolor* | Emergent | Afrotropical |
| | | *Sporobolus consimilis* | Emergent | ? |
| | | *Sporobolus ioclados* | Emergent | Afrotropical |
| | | *Urochloa trichopus* | Emergent | Afrotropical |
| | | *Vetiveria nigritana* | Emergent | Afrotropical |
| | | *Vossia cuspidata* | Emergent | Afrotropical |
| | Pontederiaceae | *Eichhornia crassipes !!* | Submerged | Afrotropical |
| | Typhaceae | *Typha domingensis* | Emergent | ? |
| Dicotyledons | Acanthaceae | *Blepharis maderaspatensis* | Herb | ? |
| | | *Barleria spinulosa* | Shrub | ? |
| | | *Duosperma quadrangulare* | Herb | ? |
| | | *Isoglossa floribunda* | Herb | ? |
| | | *Justicia glabra* | Herb | ? |
| | Amaranthaceae | *Achyranthes aspera* | Herb | Afrotropical |
| | | *Alternathera nodiflora !!* | Herb | Afrotropical |
| | | *Alternathera pungens !!* | Herb | Afrotropical |
| | | *Alternathera sessilis* | Submerged | Afrotropical |
| | Apocynaceae | *Pergularia daemia* | Liana | ? |
| | | *Tacazzea apiculata* | Emergent | Afrotropical |
| | Asteraceae | *Ambrosia maritima* | Herb | ? |
| | | *Gnaphalium polycaulon* | Herb | ? |
| | | *Melanthera scandens* | Herb | ? |
| | | *Mikania natalensis* | Herb | Afrotropical |
| | | *Nidorella auriculata* | Herb | ? |
| | | *Sphaeranthus angolensis* | Herb | ?Southern Africa |
| | | *Veronia glabra* | Shrub | Afrotropical |
| | Bignoniaceae | *Kigelia africana* | Tree | Afrotropical |
| | | *Cordia pilosissima* | Tree | Southern Africa |
| | Boraginaceae | *Heliotropium baclei* | Herb | Afrotropical |
| | | *Heliotropium indicum* | Herb | Afrotropical |
| | | *Heliotropium ovalifolium* | Herb | Afrotropical |
| | Brassicaceae | *Rorripa micrantha* | Herb | Afrotropical |
| | Ceratophyllaceae | *Ceratopyllum demersum* | Submerged | Afrotropical |
| | | *Ceratophyllum submersum* | Submerged | ? |
| | Chenopodiaceae | *Chenopodium amrbosioides* | Herb | Afrotropical |
| | Clusiaceae | *Garcinia livingstonei* | Tree | Afrotropical |
| | Combretaceae | *Combretum imberbe* | Tree | Southern Africa |
| | | *Combretum microphyllum* | Tree | Southern Africa |
| | | *Combretum mossambicense* | Tree | Southern Africa |
| | | *Combretum padoides* | Tree | Afrotropical |
| | Connaraceae | *Rourea orientalis* | Tree | Afrotropical |

| Group | Family | Species | Life form | Distribution |
|---|---|---|---|---|
| | Convulvulaceae | *Ipomoeae aquatica* | Submerged | Afrotropical |
| | | *Ipomoeae rubens* | Emergent | Afrotropical |
| | | *Ipomoeae sinensis* | Herb | Afrotropical |
| | Cucurbitaceae | *Cucumis metuliferus* | Liana | Afrotropical |
| | Euphorbiaceae | *Acalypha ornata* | Shrub | Afrotropical |
| | | *Acalypha pubiflora* | Shrub | Afrotropical |
| | | *Antidesma venosum* | Shrub | Afrotropical |
| | | *Croton megalobotrys* | Tree | Southern Africa |
| | | *Phyllanthus reticulatus* | Shrub | Afrotropical |
| | Fab:Caesalpinioideae | *Cordyla africana* | Tree | Afrotropical |
| | Fab:Mimosoideae | *Acacia tortilis* | Tree | Afrotropical |
| | | *Acacia xanthophloea* | Tree | Afrotropical |
| | | *Faidherbia albida* | Tree | Afrotropical |
| | | *Mimosa pigra* | Tree | Afrotropical |
| | | *Neptunia oleracea* | Submerged | Afrotropical |
| | Fab:Papilionoideae | *Aeschynomene indica* | Herb | Afrotropical |
| | | *Desmodium salicifolium* | Herb | Afrotropical |
| | | *Lablab purpureus* | Liana | Afrotropical |
| | | *Lonchocarpus capassa* | Tree | Southern Africa |
| | | *Phosphocarpus scandens* | | Afrotropical |
| | | *Sesbania bispinosa* | Tree | Afrotropical |
| | | *Sesbania rostrata* | Tree | Afrotropical |
| | | *Sesbania tetraptera* | Herb | Southern Africa |
| | | *Vigna luteola* | Emergent | Afrotropical |
| | | *Vigna vexillata* | Liana | Afrotropical |
| | | *Xanthoceris zambesiaca* | Tree | Southern Africa |
| | Haloragaceae | *Myriophyllum spicatum* | Submerged | Afrotropical |
| | Lentibulariaceae | *Utricularia gibba* | Submerged | Afrotropical |
| | | *Utricularia inflexa* | Submerged | Afrotropical |
| | | *Utricularia stellaris* | Submerged | Afrotropical |
| | Lythraceae | *Ammannia auriculata* | Herb | Afrotropical |
| | | *Ammannia senegalensis* | Herb | Southern Africa |
| | Malvaceae | *Hibiscus diversifolius* | Emergent | Afrotropical |
| | Meliaceae | *Trichelia emetica* | Tree | Afrotropical |
| | Molluginaceae | *Glinus lotoides* | Herb | Afrotropical |
| | | *Glinus oppositifolius* | Herb | Afrotropical |
| | | *Mollugo nudicaulis* | Herb | Afrotropical |
| | Moraceae | *Ficus capreifolia* | Emergentt | Afrotropical |
| | Nymphaeceae | *Nymphaea nouchali* | Sa | ?Southern Africa |
| | Olaceae | *Jasminium fluminense* | Shrub | Afrotropical |
| | Onagraceae | *Ludwiggia erecta !!* | Emergent | Afrotropical |
| | | *Ludwiggia leptocarpa* | Emergent | Afrotropical |
| | | *Ludwiggia octovalvis* | Herb | Afrotropical |
| | | *Ludwiggia stolonifera* | Submerged | Afrotropical |
| | Polygonaceae | *Persicaria attenuata* | Emergent | Afrotropical |
| | | *Persicaria senegalensis* | Emergent | Afrotropical |
| | Rubiaceae | *Kohautia cuspidata* | Emergent | Southern Africa |
| | | *Oldenlandia lancifolia* | Herb | Afrotropical |
| | | *Pavetta cataractarum* | Shrub | ? |
| | Scrophulariaceae | *Lindernia parviflora* | Herb | Afrotropical |
| | | *Striga forbessi* | Herb | Afrotropical |
| | Sphenocleaceae | *Sphenoclea zeylanica* | Emergent | Afrotropical |
| | Sterculiaceae | *Melochila corchorifolia* | Shrub | Afrotropical |
| | Tiliaceae | *Grewia flavescens* | Shrub | Southern Africa |
| | | *Grewia inaequilatera* | Shrub | Southern Africa |
| | | *Truimfetta pentrandra* | Shrub | Afrotropical |
| | Trapaceae | *Trapa natans* | Submerged | Afrotropical |
| | Verbenaceae | *Phyla nodiflora* | Emergent | Afrotropical |
| | | *Premna senensis* | Emergent | Afrotropical |
| | Vittacea | *Cissus grisea* | Liana | Southern Africa |

## 2.2 Methods

### 2.2.1 Survey sites

Of the six wetland habitats expected to occur in the Elephant Marsh four were mapped out on an aerial image (Figure 5). These were lakes, cultivated floodplain, marsh and river banks (by mapping river channels). Sandbars and river channels were excluded as potential sites as they were not expected to be sufficiently well vegetated to warrant sampling.

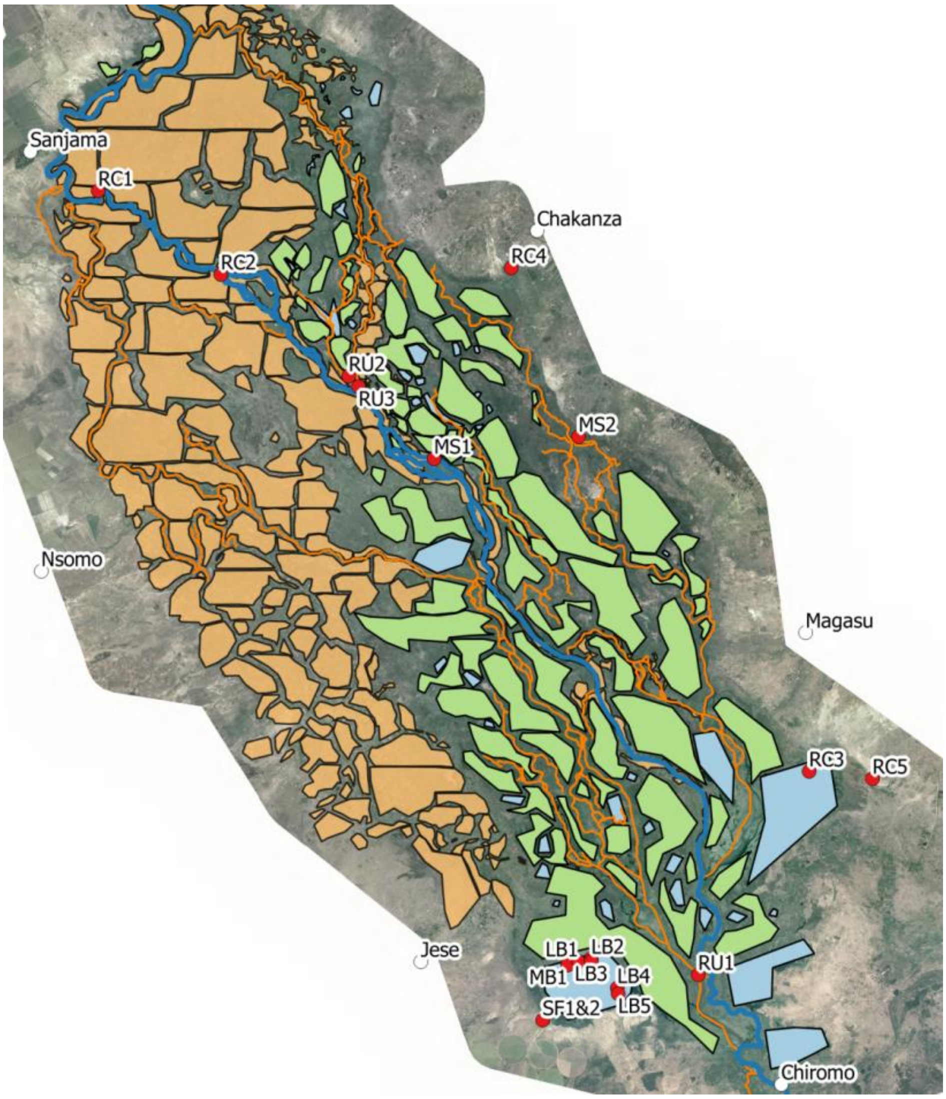


**Figure 5. Vegetation habitats, study site locations and nearby towns (site codes as per Table 7); cultivated fields on floodplain (light brown), marsh (green), lake (blue), Shire River channel (dark blue), secondary river channels (orange).**

Some areas remain uncategorised as it was not possible at this scale to distinguish these as floodplain or marsh. This map guided the selection of study sites in the four main vegetation habitats while in the field (Figure 7); lakes, marsh, floodplains and river banks, which were split into uncultivated and cultivated sites *in situ* as these were expected to differ floristically.

As per the inception report, the aim was to collect two replicate samples from five habitats, with a total of 10 samples. During the field trip however, additional samples were collected from the lakes, marsh and river channels as time and access allowed, resulting in a total of 18 study sites. A short description of the study sites is provided in Table 7 along with their coordinates and their location (Figure 5, Figure 6).

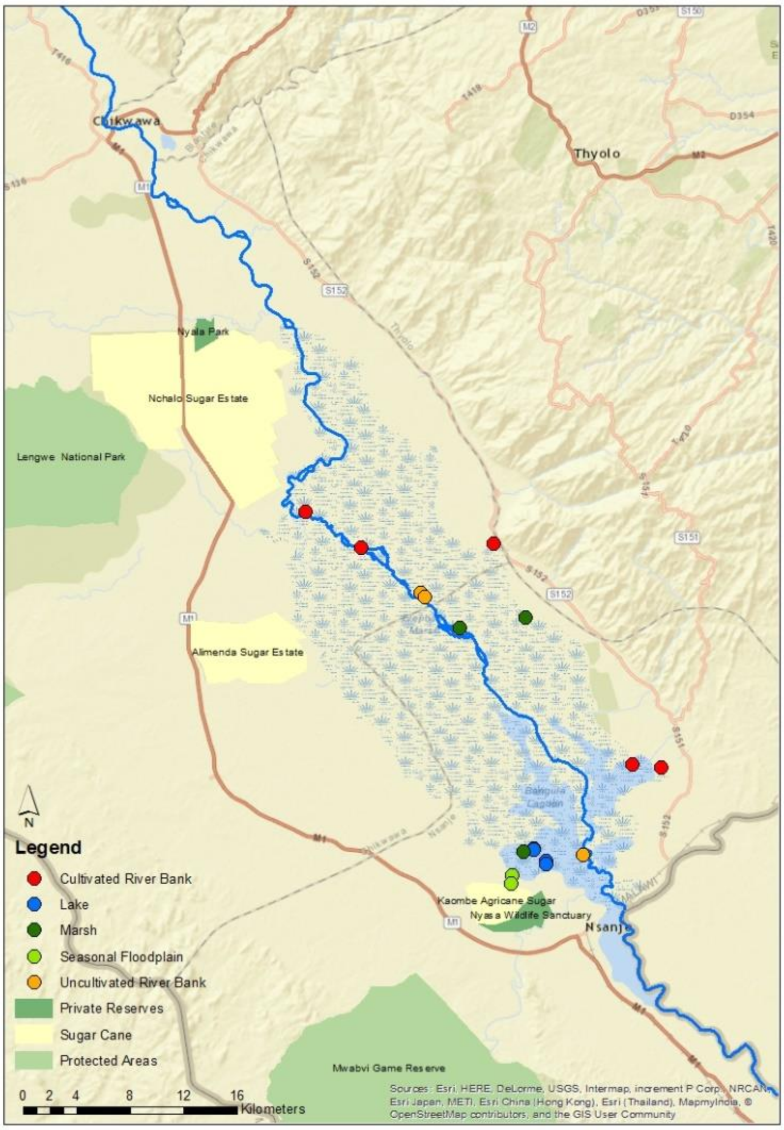


**Figure 6. Location of the sampling sites.**

Data collection was affected by access difficulties. These were related to a combination of the size of the marsh, the slow speed of travel, the damage sustained to the eastern road during the January 2015 floods (which rendered it impassable in places), and the limited availability and reach of motorised boats. These issues notwithstanding, the targeted minimum of two distinct sites were sampled in each of five different wetland habitats of the marsh.

**Table 7. Location and habitat type of the vegetation sites.**

| Code | Sample type | Habitat description | Latitude (S) | Longitude (E) |
|---|---|---|---|---|
| LB1 | Aquatic | Lake – Bangula lagoon | 16°30′54.7″ | 35°05′07.8″ |
| LB2 | | Lake – Bangula lagoon | 16°30′58.0″ | 35°05′07.8″ |
| LB3 | | Lake – Bangula lagoon | 16°31′25.7″ | 35°05′37.0″ |
| LB4 | | Lake – Bangula lagoon | 16°31′31.8″ | 35°05′37.7″ |
| LB5 | | Lake – Bangula lagoon | 16°31′01.9″ | 35°04′41.9″ |
| MB1 | Non aquatic | Marsh – Bangula lagoon | 16°22′03.7″ | 35°02′08.9″ |
| MS1 | | Marsh – Shire River | 16°21′38.9″ | 35°04′48.0″ |
| MS2 | | Marsh – Shire River | 16°32′01.0″ | 35°04′14.9″ |
| SF1 | | Seasonal floodplain – Bangula lagoon | 16°32′20.4″ | 35°04′13.1″ |
| SF2 | | Seasonal floodplain – Bangula lagoon | 16°31′10.9″ | 35°07′05.9″ |
| RU1 | | Shire River bank – uncultivated | 16°20′37.0″ | 35°00′33.8″ |
| RU2 | | Shire River bank – uncultivated | 16°20′47.8″ | 35°00′44.6″ |
| RU3 | | Shire River bank – uncultivated | 16°17′21.8″ | 34°55′55.9″ |
| RC1 | | Shire River bank – cultivated | 16°18′49.7″ | 34°58′11.6″ |
| RC2 | | Shire River bank – cultivated | 16°27′32.8″ | 35°09′05.8″ |
| RC3 | | Ruo River bank – cultivated | 16°18′40.0″ | 35°03′31.7″ |
| RC4 | | Chizimbi River bank – cultivated | 16°27′40.0″ | 35°10′16.0″ |
| RC5 | | Ruo River alluvium – cultivated | 16°30′54.7″ | 35°05′07.8″ |

### 2.2.2 Data collection

Two kinds of data were collected:

- Cover abundance data were recorded in sample plots at each survey site, which were used to prepare community descriptions and plant species lists for each site.
- A plant species list was developed through collections at the sites and between the sites to maximise the possibility of encountering a plant of conservation interest.

For aquatic species, the percentage cover in 5x5 m sample plots was estimated visually from a boat. Specimens of unknown species were collected, pressed and taken to the Zomba National Herbarium by Hassam Patel for identification.

For non-aquatic species on the river banks and at marsh edges, the percentage cover of plant species was estimated using sample plots of different sizes. Larger plant species associated with reeds, trees and shrubs were recorded in 10x10 m sample plots, while smaller graminoids and groundcovers were recorded in 5x5 m sample plots. The number of stems present and average stem height of the reeds were also recorded[2].

[2] These data were supplied to the ecosystem services team as requested and are not analysed in this report.

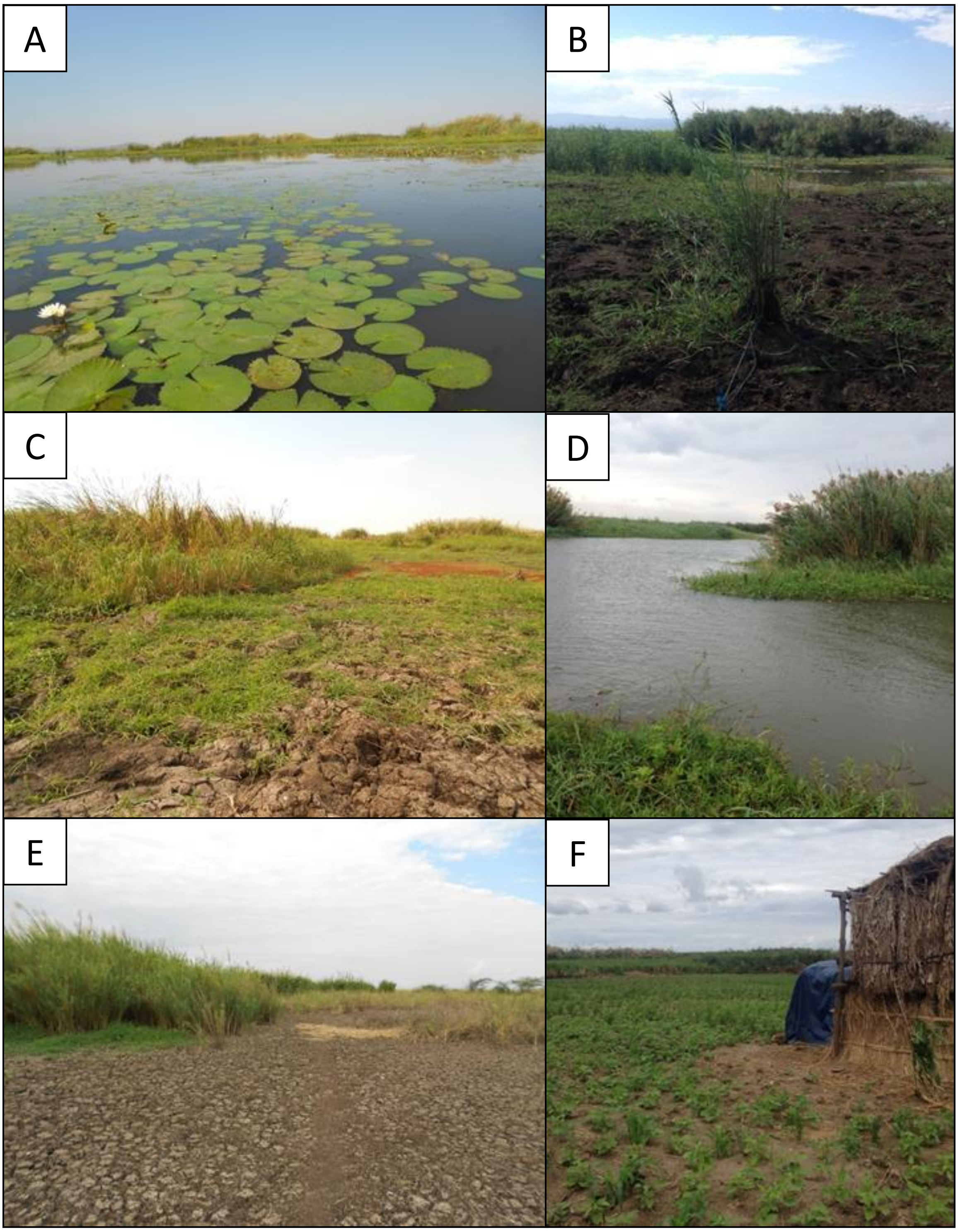


**Figure 7. A) Lake habitat at Bangula Lagoon, B) Marsh habitat on Shire River, C) Marsh habitat at Bangula Lagoon, D) Uncultivated Shire River bank habitat E) Seasonal floodplain habitat at Bangula Lagoon and F) Cultivated Shire River bank habitat (Photos: K. Reinecke).**

### 2.2.3 Data analysis

The analyses were designed to interrogate the species-level differences between the five vegetation habitats. The ANOSIM test (analysis of similarities, Clarke & Warwick 2001), a non-parametric permutation procedure analogous to ANOVA, was used to determine significance of separation between habitats. Multivariate analyses (PRIMER V6, Clarke & Warwick 2006) were used to discern relationships between habitats based on species–level similarities. Data were standardised to account for differences in abundance between different sample plot sizes, and then 4$^{th}$ root transformed to boost the presence of smaller species at lower covers. Bray-Curtis similarity coefficients were calculated between habitats and the results were displayed using multidimensional scaling ordinations (MDS) and cluster analyses (Clarke & Gorley 2006). The cluster and MDS analyses display the relationships between samples based on their species similarity. The SIMPER (similarity percentages) routine in PRIMER (V6, Clarke & Warwick 2006) was used to determine which species are responsible for the similarities and differences in the species composition of the different habitats. Different measures of biodiversity were used to rank the habitats against each one another overall. The following measures of diversity were calculated for each sample plot and averaged for each habitat: the number of species; the number of individuals; Margalef's species richness; Pielou's measure of dominance; Shannon Weiner's; and Simpson's indices (Zar 1996).

Finally, the Vegetation Response and Assessment Index (VEGRAI, Kleynhans *et al.* 2007) was used to estimate the reference (natural or undisturbed) state of the plant communities in order to evaluate their relative 2015 ecological condition. VEGRAI is a tool to calculate the ecological condition of riparian vegetation communities and has been used successfully for this purpose in other southern African aquatic ecosystems. The model is a metric-based scoring system to rank causes for change between a hypothetical reference condition, based on available literature and expert judgement, and the relative 2015 vegetative ecological condition, based on data collected. The main categories of change considered include: plant removal, presence of exotic species, changes in water quantity (flow) and quality; for woody and non-woody plant community members separately and then combined.

## 2.3 Description of current vegetation and plant species

### 2.3.1 Species list

A full plant species list, with conservation status denoted where relevant, is provided in Appendix 1. None of the plant species recorded was of conservation interest or concern (www.iucnredlist.org, accessed 1$^{st}$ February 2016). *Borassus aethiopicum* (borassus palm or *muvo*) was listed as endangered in an FAO[3] report on plant genetic resources (MG 1996) but is not currently listed in the IUCN red data list and is widespread throughout tropical Africa[4]. This species is used for the construction of mokoros (Turpie *et al.* 1999). In this study *Borassus aethiopicum* was found on the seasonal floodplain adjacent to Bangula Lagoon (SF2) and also on a cultivated river bank of the Shire River (RC1; Table 8). Recruiting palm saplings were also found on the cultivated fields. Historically,

[3] Food and Agricultural Organisation

[4] (https://en.wikipedia.org/wiki/Borassus_aethiopum, accessed 1$^{st}$ February 2016

there were vast stands of two species of palms on the north-eastern bank of the Elephant Marsh, but these no longer exist; the wild date palm *Phoenix reclinata* (Blackmore *et al.* 1988, Hughes & Hughes 1992) and the Borassus palm *Borassus aethiopicum* (this study).

Across all habitats and in general, the most abundant plants were common reed *Phragmites australis,* bulrush *Tyhpa domingensis,* hippo grass *Vossia cuspidata* and papyrus sedge *Cyperus papyrus* (Table 9), which were also the dominant species occupying marsh habitats. The most common plants of the floodplains were common reed, bulrush and vlei grass (*Miscanthus junceus*). Common reed, bulrush and papyrus sedges were more abundant on uncultivated river banks but were also present on cultivated river banks, along with crops not found elsewhere; beans, maize *Zea mays* and kweek (grazing grass) *Cynodon dactylon.*

Water lettuce *Pistia stratioites* and the white lotus (lily) *Nymphaeae lotus* were both common at marsh and lake habitats and along uncultivated river banks (Table 10). These two species were not dominant at cultivated banks where hippo grass, morning glory *Ipmoeae aquatica* and Guinea grass were common. Hornwort *Ceratophyllum demersum* and white lotus were more dominant in the lakes than the exotic water lettuce.

**Figure 8. View of Elephant Marsh from microlight**

**Table 8. Reed, tree and shrub species. Site codes as per Table 7.**

| | Marsh | | | Floodplain | | Uncultivated | | | Cultivated | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | **MB1** | **MS1** | **MS2** | **SF1** | **SF2** | **RU1** | **RU2** | **RU3** | **RC1** | **RC2** | **RC3** | **RC4** | **RC5** |
| *Acacia hebeclada* | | | | | x | | | | | | | | |
| *Aeschynomene elaphroxylon* | | | x | | | | | | | | | | |
| *Ageratum houstoniana* | | x | | | | | | | | | | | x |
| *Amaranthus hybridus* | | | | | | | | | | | | | |
| Azoaceae sp. | | | | | | | | | | | | | x |
| Banana | | x | | | | | | | x | x | | | |
| Beans | | x | | | | | | | x | | | | |
| *Boerhaula diffusa* | | | | | | | | | | | | x | |
| *Borassus aethiopicum* | | | | | x | | | | x | | | | |
| *Brassela* sp. | | | | | | | | | | | | | |
| *Bridelia cathartica* | | | | | x | | | | | | | | |
| *Carex cognata* | | | | | | | | | | | | x | |
| *Celosia trigyna* | | | | | | | | | | | | x | |
| *Chamaechrista hirta* | | | | | | | | | | | | x | |
| *Cissampelos mucranata* | | | | | | | | | x | | | | |
| *Cliffortia* sp. | x | | | | | | | | | | | | |
| *Combretum microphyllum* | | | | | | | | | | | | x | |
| *Commelina africana* | x | | | | | | | | | | | | |
| *Commelina benghalensis* | x | | | | | x | | x | | | | | |
| *Commelina diffusa* | | | | | | | x | | | | | | |
| *Commiphora marlothii* | | | | | x | | | | | | | | |
| *Cynodon aethiopicus* | | | | x | | | | | | | | | x |
| *Cynodon dactylon* | | | | | | | | | | x | | | x |
| *Cyperus asterifolia* | | | | | | | | | | | | | x |
| *Cyperus papyrus* | x | x | x | | | x | x | x | | | x | | |
| *Desmodium salicifolium* | | | | | | x | | | | | | | |
| *Echinochloa pyramidalis* | | x | | | | | | | | | | | x |
| *Eclipta prostrata* | | | | | | | x | | | | | | |
| *Eucalyptus* sp. | | | | | | | | | | x | | | |
| *Faidherbia albida* | | | | | | | | | | | | x | |
| *Ficus exasperata* | | | | | | | | | x | | | | |
| *Ficus sycamorus* | | | | | | | | | | x | | x | |
| *Galinsoga parviflora* | | x | | | | | | | | | | | |
| *Hibiscus diversifolius* | x | | | | | | | x | | | | | |
| *Ipmoea aquatica* | x | x | x | | | x | | | | x | x | | x |
| *Ipmoea convulvis* | | | | | | | | | | | | x | |
| *Leonoitis nepetifolia* | | | | | | | | | | | | x | |
| Lettuce | | | | | | | | | x | | | | |
| *Ludwiggia heptoclada* | | | | | | | | | | | | | x |
| *Ludwiggia leptocarpa* | x | | | | | | | | | | | | x |
| *Ludwiggia stolonifera* | | | | | | | x | | | | | | x |
| *Luffa cylindrica* | | | | | | x | | | | x | | | |
| *Mariscus thunbergii* | | | | | | | | | | | | | x |
| *Miscanthus junceus* | | | | x | | | | | | | | | |
| *Momordica foetida* | | | | | x | | | | | | | | |
| *Nidorella virgatum* | | | | | | | | | | | | x | |
| *Nymphaea* sp. (dry) | | | | x | | | | | | | | | |
| *Ocimum cannum* | | | | | | | | | | | | x | |
| *Panicum maximum* | | | | | | | | x | | | | x | |
| Peas | | | | | | | | | | | | x | |
| *Persicaria senegalensis* | x | x | | | | | | | | | | | |
| *Phragmites australis* | | x | x | | | | x | x | | x | x | | x |
| *Phragmites mauritianus* | x | | | x | | x | | | | | | | |
| *Pycreus mundtii* | | | | | | | x | x | | | | | x |
| Rice | | | | | | | | | | | | x | |
| *Ricinus communis* | | | | | | | | | | | | x | |
| *Rorripa fluviatilis* | | | | | | | | | | | | | x |
| *Senna occidentalis* | | | | | | | | | x | | | x | |

| | Marsh | | | Floodplain | | Uncultivated | | | Cultivated | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | **MB1** | **MS1** | **MS2** | **SF1** | **SF2** | **RU1** | **RU2** | **RU3** | **RC1** | **RC2** | **RC3** | **RC4** | **RC5** |
| *Sesbania bispinosa* | | | | | x | | | | | | | | |
| *Sesbania hirsuta* | | | | | | | | | x | | | | |
| *Solanum incanum* | | | | | | | | | | | | | x |
| *Solanum nigrum* | | | | | | | | | | | | | x |
| *Spilanthes mauritiana* | | x | | | | | | | | | | | |
| *Thelypteris hispidula* | | | | | | | | | x | | | | |
| Tomatoes | | | | | | | | | | | | x | |
| *Tridix procumbens* | x | | x | x | | | | | | | | x | |
| *Vigna vexillata* | x | | | | | x | | | | | | | |
| *Vossia cuspidata* | x | | x | | | x | x | x | x | | x | | |
| *Zea mays* | | | | | | | | | x | x | | x | x |
| *Ziziphus mauritianus* | | | | | | | | | | x | | | |

**Table 9. Cover, as a percentage of total recorded (10m$^2$), and frequency of occurrence (F) of dominant reed, shrub and tree species per habitat.**

| | Marsh (n=3) | | Floodplain (n=2) | | Uncultivated (n=3) | | Cultivated (n=5) | |
|---|---|---|---|---|---|---|---|---|
| **Species** | **% cover** | **F** | **% cover** | **F** | **% cover** | **F** | **% cover** | **F** |
| *Phragmites australis* | 27 | 67 | 26 | 50 | 19 | 67 | 10 | 60 |
| *Vossia cuspidata* | 24 | 67 | | | 27 | 100 | 10 | 40 |
| *Typha domingensis* | 22 | 67 | 5 | 50 | | | 3 | 20 |
| beans | 14 | 33 | | | | | 1 | 20 |
| *Cyperus papyrus* | 10 | 100 | | | 26 | 100 | 8 | 20 |
| *Ludwiggia leptocarpa* | 10 | 33 | | | | | 1 | 20 |
| *Ipmoea aquatic* | 9 | 100 | | | | | 4 | 60 |
| *Polygonum senensis* | 6 | 67 | | | | | | |
| *Miscanthus junceus* | | | 21 | 50 | | | | |
| *Acacia hebeclada* | | | 16 | 50 | | | | |
| *Pycreus mundtii* | | | | | 9 | 67 | 2 | 20 |
| *Commenlina benegalensis* | | | | | 3 | 67 | | |
| *Zea mays* | | | | | | | 15 | 80 |
| *Cynodon dactylon* | | | | | | | 4 | 40 |
| *Ficus sycamorus* | | | | | | | 4 | 40 |
| *Sesbania sesban* | | | | | | | 3 | 40 |

**Table 10. Cover, as a percentage of total recorded (5m$^2$), and frequency of occurrence (F) of graminoids, groundcovers and aquatic species per habitat.**

| | Marsh (n=4) | | Floodplain (n=2) | | Uncultivated (n=6) | | Cultivated (n=5) | | Lake (n=5) | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | **% cover** | **F** | **% cover** | **F** | **% cover** | **F** | **% cover** | **F** | **% cover** | **F** |
| *Pistia stratioites* | 15 | 50 | | | 12 | 100 | | | 24 | 40 |
| *Nymphaea lotus* | 15 | 25 | | | 13 | 67 | | | 31 | 60 |
| *Vossia cuspidata* | 15 | 25 | | | 7 | 67 | 7 | 40 | | |
| *Miscanthus junceus* | | | 29 | 50 | | | | | | |
| *Ceratophylum demersum* | | | 18 | 50 | | | | | 43 | 80 |
| *Nymphaea lotus* | | | 7 | 50 | | | | | | |
| *Sesbania tetrana* | | | 4 | 50 | | | | | | |
| *Ipmoea aquatica* | | | | | 8 | 83 | 10 | 40 | | |
| *Azolla pinnata* | | | | | 8 | 83 | | | | |
| *Panicum maximum* | | | | | | | 3 | 40 | | |

**Table 11. Gramminoids, groundcovers and aquatic species. Site codes as per Table 7.**

| | Marsh | | | | Floodplain | | Uncultivated | | | | | | Cultivated | | | | | Lake | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **MB1** | **MB2** | **MS1** | **MS2** | **SF1** | **SF2** | **RU1** | **RU2** | **RU3** | **RU4** | **RU5** | **RU6** | **RC1** | **RC2** | **RC3** | **RC4** | **RC5** | **LB1** | **LB2** | **LB3** | **LB4** | **LB5** |
| *Ageratum houstoniana* | | | | | | | | | | | | | x | | | | | | | | | |
| *Amaranthus lividus* | | | | | | | | | | | | | x | | | | | | | | | |
| *Ammania prieuriana* | | | | | | | | | x | | | | | | | | | | | | | |
| *Argemone mexicana* | | | | | | | | | | | | | | | | | x | | | | | |
| *Azolla filliculoides* | | | | | | | | x | | | x | | | | | | | | | | | |
| *Azolla pinnata* | x | | | | | | x | x | x | x | | x | | | | x | | | | | | |
| *Baracillia* sp. | | | | | | | | | x | | | | | | | | | | | | | |
| *Blepharis acanthodioides* | | | | | | | | | | | | | | | | | x | | | | | |
| *Bracillis* sp. | | | x | | | | | | | | | | | | | | | | | | | |
| *Ceratophyllum demersum* | | x | | | | x | | | | x | x | | | | | x | | x | x | x | | x |
| *Chamaechrista indica* | | | | | | | | | | | | | x | | | | | | | | | |
| *Chenopodium album* | | | | | | | | | | | | | x | | | | | | | | | |
| Coco cultivated | | | x | | | | | | | | | | | | | | | | | | | |
| *Commelina benghalensis* | | | x | | | | | x | | | | | | | | | | | | | | |
| *Commelina diffusa* | | | | | | | | | | | | | | x | | | | | | | | |
| *Conyza stricta* | | | x | | | | | | | | | | | | | | | | | | | |
| *Crotolaria erecta* | | | | | | | | | | | | | x | | | | | | | | | |
| *Cynodon dactylon* | x | | | | | | | | | | | | | x | | | | | | | | |
| *Cyperus articulatus* | x | | | | | | | | | | | | | | | | | | | | | |
| *Cyperus asterifolia* | | | x | | | | | | | | | | | | | | | | | | | |
| *Cyperus aterrimus* | x | | x | | | | | | | | | | | | | | | | | | | |
| *Cyperus cyperoides* | | | | | x | | | | x | | | | | | | | | | | | | |
| *Cyperus denudatus* | | | | | | | | | x | | | | | | | | | | | | | |
| *Cyperus distans* | x | | | | | | | | | | | | | | | | | | | | | |
| *Cyperus longifolia* | | | | | | | | | | | | | | | | | x | | | | | |
| *Cyperus tenuifolius* | | | | | | | | | x | | | | | | | | | | | | | |
| *Digitaria algonia* | | | | | | | | | | | | | | | | | x | | | | | |
| *Echinochloa pyramidalis* | | | | | | | | | x | | | | | x | | | | | | | | |
| *Eclipta prostrata* | | | | | | | | | | | | | | | | | x | | | | | |
| *Eichornia crassipes* | x | | | | | | x | | | x | | | | | x | | | | | | | |
| *Eragrostis fastigiata* | | | | | | | | | x | | | | x | | | | | | | | | |
| *Eragrostis racemosa* | | | | | | | | | | | | | | | | | x | | | | | |
| *Glinus lotoides* | x | | | | | | | | | | | | | | | | | | | | | |
| *Gnaphalium polycaulon* | | | | | | | | | | | | | x | | | | x | | | | | |
| *Gnoglossum indica* | | | | | | | | | | | | | x | | | | | | | | | |

| | Marsh | | | | Floodplain | | Uncultivated | | | | | | Cultivated | | | | | Lake | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MB1 | MB2 | MS1 | MS2 | SF1 | SF2 | RU1 | RU2 | RU3 | RU4 | RU5 | RU6 | RC1 | RC2 | RC3 | RC4 | RC5 | LB1 | LB2 | LB3 | LB4 | LB5 |
| *Hibiscus diversifolius* | | | x | | | | | | | | | | | | | | | | | | | |
| *Ipmoea aquatica* | | | | x | | | x | x | | x | x | x | | x | x | | | | | | | |
| *Kyllinga alba* | | | | | | | | | x | | | | | | | x | | | | | | |
| *Leersia hexandra* | | | | | | | | | | | | | | x | | | | | | | | |
| *Ludwiggia heptoclada* | | | | | | | | | | | | | | | | x | | | | | | |
| *Ludwiggia leptocarpa* | | | | | | | x | | x | | | | | | | | | | | | | |
| *Ludwiggia stolonifera* | x | | | | | | | | | | x | x | | | x | | | | | | | |
| *Melanthera scandens* | | | | | | | | | | | | | | x | | | | | | | | |
| *Mikania cordata* | | | x | | | | | | | | | | | | | | | | | | | |
| *Mimosa pigra* | | | | | | | | | | | | | x | | | | | | | | | |
| *Miscanthus junceus* | | | | | x | | | | | | | | | | | | | | | | | |
| *Nidorella resedens* | | | | | | | | | | | | | x | | | | | | | | | |
| *Nymphaea lotus* | | x | | | | x | x | | | x | x | x | | | | x | | x | x | | | x |
| *Nymphaea petersianna* | | | | | | | | | | | x | | | | | | | | | | | |
| *Ocimum cannum* | | | | | | | | | | | | | x | | | | | | | | | |
| *Ottelia exserta* | | | | | | | | | | | x | x | | | | x | | | | | | |
| *Panicum maximum* | | | | | | | | | | | | | x | x | | | | | | | | |
| *Persicaria decipiens* | | | | | | | | x | | | | | | | | | | | | | | |
| *Persicaria nigrescens* | | | | | | | | | | | | | | | | | x | | | | | |
| *Persicaria senegalensis* | | | | | | | | | x | | | | | | | | | | | | | |
| *Phragmites australis* | | | | | | | | | | | | | | x | | | | | | | | |
| *Pistia stratiotes* | x | | | x | | | x | x | x | x | x | x | | | | x | | | x | | x | |
| *Polygala variegata* | | | | | | | | | | | | | x | | | | | | | | | |
| *Pycreus mundtii* | | | | | | | x | x | | | | | | | x | | | | x | | | |
| *Reseda* sp. | x | | | | | | | | | | | | | | | | | | | | | |
| *Ricinus communis* | | | | | | | | | | | | | x | | | | | | | | | |
| *Rumex abyssinica* | | | | | | | | | | | | | x | | | | | | | | | |
| *Rumex acetosella* | | | x | | | | | | | | | | | | | | x | | | | | |
| *Salvinia molesta* | | | | | | | | | | | | | x | | | | | | | | | |
| *Sesbania indica* | | | | | | | x | | | | | | | | | | | | | | | |
| *Sesbania leptocarpa* | | | | | x | | | | | | | | | | | | | | | | | |
| *Setaria sphacelata* | | | | | | | | | | | | | x | | | | | | | | | |
| Sugar cane | | | | | | | | | | | | | | | x | | | | | | | |
| *Trichodesma zeylamicum* | | | x | | | | | | | | | | | | | | | | | | | |
| *Tridix procumbens* | | | | x | | | | | | | | x | | | | | | | | | | |
| *Vossia cuspidata* | | | | x | | | x | x | | x | | x | | | x | x | | | | | | |
| *Ziziphus mauritianus* | | | | | | | | | | | | | x | | | | | | | | | |

**Figure 9. Photographs of the dominant plant species mentioned in Table 9 and Table 10. (L-R, Top-Bottom) Papyrus *Cyperus papyrus,* Common reed *Phragmites australis,* Hippo grass V*ossia cuspidata,* Hornwort *Ceratophyllum demersum,* White lotus *Nymphaea lotus,* Water fern *Azolla filiculloides,* Red water fern *Azolla pinnata* (with juvenile water hyacinth *E. crassipes* at centre), Water lettuce *Pistia stratioites,* Water hyacinth *Echhornia crassipes,* Vlei grass *Miscanthus junceus,* Kweek *Cynodon dactylon,* Bulrush *Typha domingensis* (Photos: K. Reinecke)**

### 2.3.2 ANOSIM analysis

In the Anosim analysis, the global $R^2$ for the test between the species differences of habitats was 0.25, indicating that the five habitats were not well-differentiated from one another. There were no statistical differences between the species composition of marsh and (uncultivated and cultivated) river banks However, there were some differences between floodplains and (uncultivated and cultivated) river banks ($R^2$ >0.65, P > 0.003%; $R^2$ >0.46, P > 0.003% respectively); and between lakes and (uncultivated and cultivated) river banks ($R^2$ >0.42 P > 0.008%; $R^2$ >0.44, P > 0.001% respectively; respectively; Table 12) worth exploring further.

**Table 12. Differences in species composition between different habitats, * denotes significance.**

| Site type | $R^2$ | P value |
|---|---|---|
| Floodplain versus uncultivated river bank | 0.65 | 0.003* |
| Floodplain versus cultivated river bank | 0.46 | 0.003* |
| Uncultivated bank versus lake | 0.45 | 0.008* |
| Cultivated bank versus lake | 0.46 | 0.001* |
| Marsh versus lake | 0.27 | 0.051 |
| Marsh versus floodplain | 0.23 | 0.051 |
| Floodplain versus lake | 0.24 | 0.071 |
| Uncultivated bank versus cultivated bank | 0.08 | 0.111 |
| Marsh versus uncultivated bank | 0.006 | 0.390 |
| Marsh versus cultivated bank | -0.04 | 0.670 |

### 2.3.3 Cluster analysis and MDS ordination

The cluster analysis and MDS ordination of the Bray-Curtis similarity between habitats is shown in Figure 10. In Figure 10, reeds, trees and shrubs are termed *reeds* and have the *suffix a* at the end of the sample code. The smaller graminoids and groundcovers are collectively termed *groundcovers* and have the *suffix b*.

The SIMPROF test differentiated seven groups:

- marsh reeds and cultivated river bank groundcovers;
- floodplain reeds and groundcovers;
- lakes and marsh groundcovers;
- cultivated river bank reeds and groundcovers with marsh reeds;
- uncultivated and cultivated river bank reeds with marsh reeds;
- uncultivated and cultivated river bank groundcovers with marsh groundcovers;
- lake and uncultivated river banks groundcovers; and
- cultivated river bank reeds and groundcovers.

There was considerable overlap of species in the eight groups. This is reflected in the low similarity coefficients between the habitats comprising groups 1, 7 and 8 in particular (<20% in each case), which were a mixture of samples from different habitats. Stronger similarity coefficients were seen for groups 2, 3, 4, 5 and 6, which were dominated by samples from the floodplain, lakes, uncultivated and cultivated river banks. Marsh samples were split across the groups and showed no clear affiliation for one another. Due to this, and that there were no floristic differences between the marsh and river bank samples, the marsh samples were excluded from the SIMPER analyses that follow.

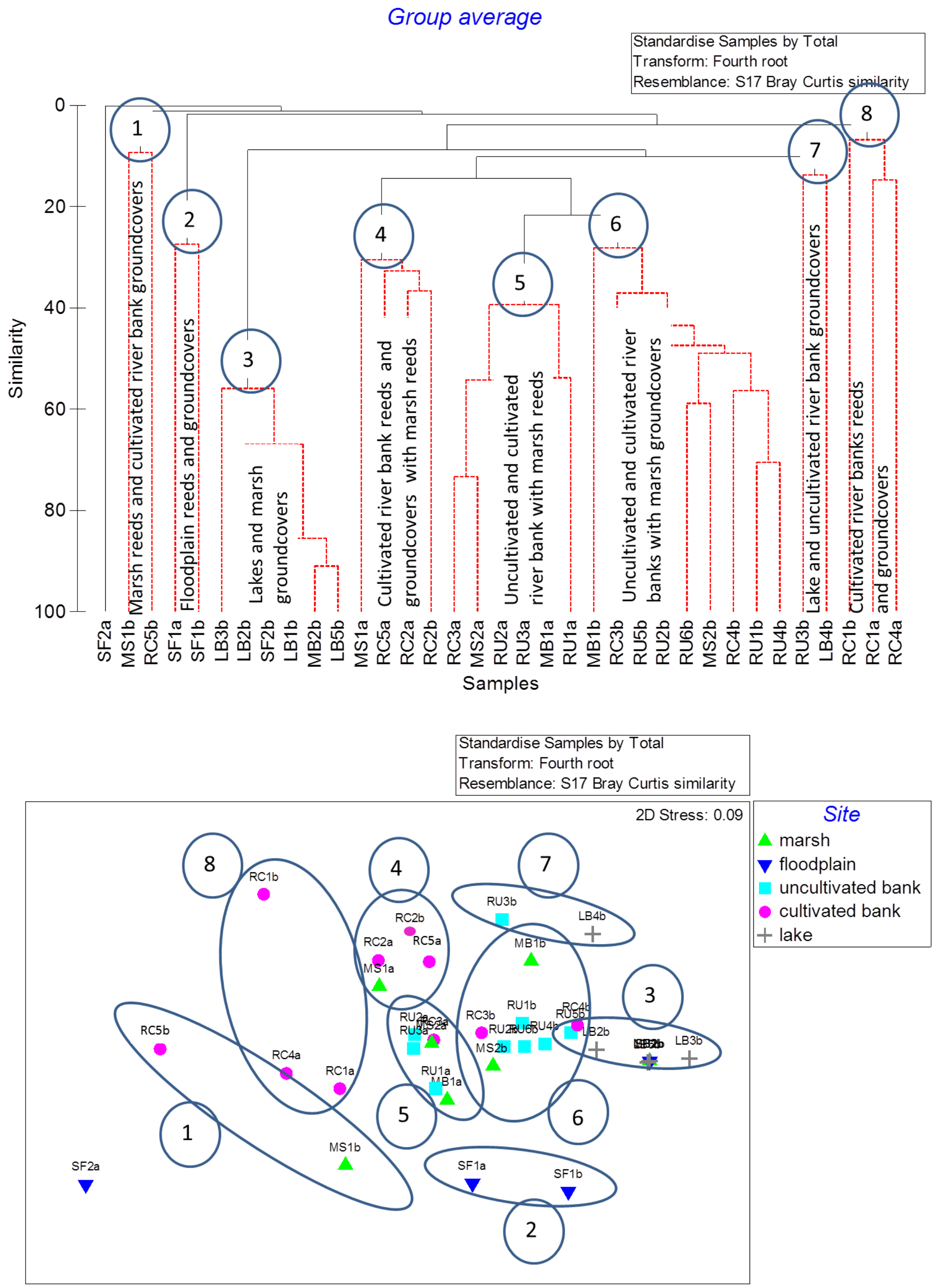


**Figure 10. Cluster analysis (top) and MDS ordination (below) of Bray-Curtis site similarity.**

### 2.3.4 SIMPER analysis

The typical (Table 13) and discriminating (Table 14) species of the floodplain, lake and river bank (uncultivated and cultivated) habitats were identified using a SIMPER analysis.

There was least overlap in the species composition of lakes and the floodplain, which were typified by hornwort *Ceratophyllum demersum* and white lotus *Nymphaea lotus; and* vlei grass *Miscanthus junceus,* respectively. There was more overlap in species in cultivated and uncultivated river banks with maize *Zea mays,* kweek *Cynodon dactylon* and antelope grass *Echinochloa pyramidalis* strongly present at cultivated banks; and water lettuce *Pistia stratiotes,* mosquito fern *Azolla pinnata,* white lotus and papyrus *Cyperus papyrus* strongly present at uncultivated banks. Water lettuce, mosquito fern and white lotus are aquatic species but they can (and do) take root on muddy banks when water levels recede (personal observation K. Reinecke July 2015). Papyrus is heavily utilised by locals so the reduced abundance of this plant on cultivated banks is not surprising; different diameter culms (flowering stalks) are used for making sleeping mats or baskets, the flower heads are used for brooms and the rhizomes are used to make charcoal. The marsh plants hippo grass *Vossia cuspidata,* common reed *Phragmites australis,* reed grass *P. mauritianus,* the sedge *Pycreus mundtii* and papyrus were common in all the habitats except for lakes.

Despite the overlap in species composition between habitats, a few species consistently discriminated three of the habitats from the others (Table 14). Maize was more common on cultivated banks than in other habitats, hippo grass *Vossia cuspidata* favoured river banks (cultivated and uncultivated) over lakes and vlei grass *Miscanthus junceus* was common in the floodplain rather than lakes.

**Table 13. Typical species of lakes, cultivated and uncultivated river banks, floodplain and the terrestrial island. Sim = similarity coefficient, SD = standard deviation.**

| Community | Species | Average similarity % | Sim/SD | Contribution % |
|---|---|---|---|---|
| Lake | *Ceratophyllum demersum* | 24.7 | 1.0 | 63.4 |
| | *Nymphaea lotus* | 11.8 | 0.6 | 30.3 |
| Cultivated river banks | *Ipmoea aquatica* | 2.4 | 0.5 | 23.8 |
| | *Vossia cuspidata* | 1.8 | 0.4 | 18.2 |
| | *Phragmites australis* | 1.6 | 0.4 | 16.5 |
| | *Zea mays* | 1.2 | 0.4 | 12.4 |
| | *Cynodon dactylon* | 0.6 | 0.3 | 6.7 |
| | *Panicum maximum* | 0.5 | 0.3 | 4.7 |
| | *Pycreus mundtii* | 0.2 | 0.2 | 2.5 |
| | *Musa* spp. | 0.2 | 0.2 | 2.0 |
| | *Echinochloa pyramidalis* | 0.2 | 0.2 | 1.8 |
| | *Ludwiggia stolonifera* | 0.2 | 0.2 | 1.6 |
| Floodplain | *Miscanthus junceus* | 4.6 | 0.4 | 100 |
| Uncultivated river banks | *Vossia cuspidata* | 7.8 | 1.1 | 26.7 |
| | *Pistia stratiotes* | 4.6 | 0.8 | 15.6 |
| | *Ipmoea aquatica* | 4.6 | 0.8 | 15.5 |
| | *Azolla pinnata* | 3.0 | 0.6 | 10.3 |
| | *Pycreus mundtii* | 2.2 | 0.4 | 7.5 |
| | *Nymphaea lotus* | 2.1 | 0.4 | 7.1 |
| | *Cyperus papyrus* | 1.3 | 0.3 | 4.5 |
| | *Ludwiggia stolonifera* | 0.9 | 0.3 | 3.2 |

**Table 14. Discriminanting species for lakes, cultivated and uncultivated river banks, floodplain and the terrestrial island. Diss = dissimilarity coefficient, SD = standard deviation.**

| Community | Species | Average dissimilarity % | Diss/SD | Contribution % |
|---|---|---|---|---|
| **Uncultivated bank vs.** | **Cultivated bank** | | | |
| | *Zea mays* | 2.3 | 0.8 | 2.8 |
| | *Cynodon dactylon* | 1.9 | 0.62 | 2.31 |
| *Commelina benghalensis* | | 1.6 | 0.68 | 1.90 |
| *Azolla filliculoides* | | 1.3 | 0.52 | 1.54 |
| | | | | |
| **Uncultivated bank vs.** | **Lake** | | | |
| *Vossia cuspidata* | | 8.5 | 1.7 | 9.9 |
| *Ipmoea aquatica* | | 6.0 | 1.3 | 7.0 |
| *Azolla pinnata* | | 4.9 | 1.1 | 5.7 |
| *Cyperus papyrus* | | 4.2 | 0.7 | 4.9 |
| *Ludwiggia stolonifera* | | 3.1 | 0.7 | 4.9 |
| *Phragmites australis* | | 2.9 | 0.5 | 3.4 |
| | | | | |
| **Cultivated bank vs.** | **Lake** | | | |
| *Ipmoea aquatica* | | 4.8 | 0.9 | 5.0 |
| *Vossia cuspidata* | | 4.2 | 0.7 | 4.9 |
| *Phragmites australis* | | 3.3 | 0.8 | 3.4 |
| *Zea mays* | | 3.0 | 0.6 | 3.1 |
| *Cynodon dactylon* | | 2.8 | 0.6 | 3.0 |
| *Panicum maximum* | | 1.9 | 0.6 | 2.0 |
| *Cyperus papyrus* | | 1.9 | 0.3 | 1.9 |
| *Echinochloa pyramidalis* | | 1.7 | 0.5 | 1.8 |
| | | | | |
| **Cultivated bank vs.** | **Floodplain** | | | |
| | *Miscanthus junceus* | 4.9 | 0.9 | 5.0 |
| *Ipmoea aquatic* | | 4.0 | 0.9 | 4.1 |
| *Vossia cuspidata* | | 3.9 | 0.7 | 4.0 |
| *Phragmites australis* | | 3.6 | 0.8 | 3.6 |
| *Zea mays* | | 2.9 | | |
| | *Acacia hebclada* | 2.5 | 0.6 | 2.5 |
| | *Cynodon dactylon* | 2.5 | 0.6 | 2.5 |
| | *Phragmites mauritianus* | 2.3 | 0.6 | 2.3 |
| | *Acacia seyal* | 1.9 | 0.6 | 1.9 |
| | | | | |
| **Floodplain vs.** | **Lake** | | | |
| *Miscanthus junceus* | | 9.3 | 0.9 | 11.1 |
| | *Pistia straioites* | 7.5 | 0.6 | 8.9 |
| *Acacia hebeclada* | | 4.3 | 0.6 | 5.1 |
| *Phragmites mauritianus* | | 4.1 | 0.6 | 4.9 |
| *Acacia seyal* | | 3.2 | 0.6 | 3.9 |
| *Tyhpa domingensis* | | 2.8 | 0.6 | 3.3 |
| | *Pycreus mundtii* | 2.6 | 0.5 | 3.1 |
| | | | | |

### 2.3.5 Plant diversity

In general, the cultivated river banks were the most vegetatively diverse (Table 13). Marsh and uncultivated river banks had similar levels of diversity, but were less diverse than the cultivated banks. The floodplain and the lakes were the least botanically diverse of the habitats. It seems counterintuitive that cultivated river banks were more species rich than the less-disturbed marsh and uncultivated river banks but this was a result of the variety and abundance of disturbance-adapted annuals, perennial forbs and grasses associated with cultivated crops. By contrast, uncultivated marsh and river banks were dominated by papyrus, the common reed *Phragmites australis* and hippo grass, leaving little room for competitors and neighbours. The measures of biodiversity are ranked in descending order (Table 15).

**Table 15. Measures of diversity for all samples and all habitats. Site codes; a = 100m$^2$ sample plot, b = 25m$^2$ sample plot. S = number of species, N = number of individuals, d = Margalef's species richness, J' = Pielou's dominance factor, H' = Shannon Weiner index, 1-lambda = Simpson's index.**

| Habitat | Site code | S | N | d | J' | H'(loge) | 1-Lambda' |
|---|---|---|---|---|---|---|---|
| Cultivated Banks | RC1a | 6 | 100 | 1.09 | 0.83 | 1.49 | 0.74 |
| | RC2a | 6 | 100 | 1.09 | 0.85 | 1.53 | 0.76 |
| | RN1a | 13 | 100 | 2.61 | 0.92 | 2.37 | 0.90 |
| | RC3a | 4 | 100 | 0.65 | 0.92 | 1.28 | 0.70 |
| | RC4a | 12 | 100 | 2.39 | 0.84 | 2.09 | 0.83 |
| | **Average** | **8** | **100** | **1.6** | **0.9** | **1.8** | **0.8** |
| | RC1b | 12 | 100 | 2.39 | 0.93 | 2.32 | 0.89 |
| | RC2b | 8 | 100 | 1.52 | 0.84 | 1.76 | 0.79 |
| | RN1b | 8 | 100 | 1.52 | 0.85 | 1.76 | 0.79 |
| | RC3b | 5 | 100 | 0.87 | 0.93 | 1.49 | 0.77 |
| | RC4b | 7 | 100 | 1.30 | 0.84 | 1.64 | 0.78 |
| | **Average** | **8** | **100** | **1.52** | **0.88** | **1.79** | **0.80** |
| Marsh | MB1a | 12 | 100 | 2.39 | 0.84 | 2.08 | 0.85 |
| | MS1a | 6 | 100 | 1.09 | 0.82 | 1.48 | 0.73 |
| | MS2a | 6 | 100 | 1.09 | 0.94 | 1.69 | 0.81 |
| | **Average** | **8** | **100** | **1.52** | **0.87** | **1.75** | **0.80** |
| | MB1b | 8 | 100 | 1.52 | 0.82 | 1.71 | 0.79 |
| | MB2b | 2 | 100 | 0.22 | 0.95 | 0.66 | 0.47 |
| | MS1b | 7 | 100 | 1.30 | 0.96 | 1.88 | 0.84 |
| | MS2b | 3 | 100 | 0.43 | 0.87 | 0.96 | 0.58 |
| | **Average** | **5** | **100** | **0.87** | **0.90** | **1.30** | **0.67** |
| Uncultivated Banks | RU1a | 8 | 100 | 1.52 | 0.85 | 1.77 | 0.79 |
| | RU2a | 7 | 100 | 1.30 | 0.83 | 1.62 | 0.78 |
| | RU3a | 7 | 100 | 1.30 | 0.81 | 1.58 | 0.76 |
| | **Average** | **7** | **100** | **1.38** | **0.83** | **1.66** | **0.78** |
| | RU1b | 7 | 100 | 1.30 | 0.95 | 1.84 | 0.84 |
| | RU4b | 5 | 100 | 0.87 | 0.97 | 1.56 | 0.79 |
| | RU2b | 6 | 100 | 1.09 | 0.79 | 1.41 | 0.71 |
| | RU5b | 6 | 100 | 1.09 | 0.82 | 1.47 | 0.71 |
| | RU3b | 11 | 100 | 2.17 | 0.88 | 2.12 | 0.85 |

| Habitat | Site code | S | N | d | J' | H'(loge) | 1-Lambda' |
|---|---|---|---|---|---|---|---|
| | RU6b | 7 | 100 | 1.30 | 0.97 | 1.89 | 0.85 |
| | **Average** | **7** | **100** | **1.30** | **0.90** | **1.72** | **0.79** |
| Floodplain | SF1a | 5 | 100 | 0.87 | 0.90 | 1.45 | 0.74 |
| | SF2a | 6 | 100 | 1.09 | 0.75 | 1.34 | 0.65 |
| | **Average** | **6** | **100** | **0.98** | **0.83** | **1.40** | **0.70** |
| | SF2b | 2 | 100 | 0.22 | 0.86 | 0.60 | 0.41 |
| | SF1b | 3 | 100 | 0.43 | 0.76 | 0.83 | 0.53 |
| | **Average** | **3** | **100** | **0.33** | **0.81** | **0.72** | **0.47** |
| Lake | LB1b | 2 | 100 | 0.22 | 0.81 | 0.56 | 0.38 |
| | LB2b | 4 | 100 | 0.65 | 0.81 | 1.13 | 0.63 |
| | LB3b | 3 | 100 | 0.43 | 0.91 | 1.00 | 0.60 |
| | LB4b | 1 | 100 | 0.00 | | 0.00 | 0.00 |
| | LB5b | 2 | 100 | 0.22 | 0.49 | 0.34 | 0.19 |
| | **Average** | **2** | **100** | **0.22** | **0.73** | **0.47** | **0.29** |

### 2.3.6 Conservation importance

A comprehensive directory of African wetlands was compiled by Hughes & Hughes (1992), which classifies African wetlands and provides a summarised account of their characteristics and ecological condition at that time. Their description of the Elephant Marsh closely resembles that of the current day but it is not known to what extent the same may be assumed for other similar aquatic ecosystems in Malawi, summarised in Table 16.

If we assume the state and extent of other similar aquatic ecosystems are as described in 1992 then the areal extent of wetland habitats similar to those found in the Elephant Marsh will be well represented in type and extent elsewhere in Malawi, and in southern Africa (Hughes & Hughes 1992, data not summarised here). In addition, neither the literature review nor the data collected during this study revealed any plant species of particular conservation importance. Many of the plant species found are generalists and common inhabitants of other Southern African aquatic ecosystems. For these reasons, from a vegetation perspective alone, the vegetation of the Elephant Marsh is not considered to be globally or nationally threatened. However, the presence and protection the wetland vegetation is worthy as it is intimately linked with the hydromorphological functioning of the Elephant Marsh (see section 1.7 of the Hydromorphological report), the provision of wetland ecosystem goods and services (see Ecosystem Services report), comprises important habitat for wildlife in general but in particular for birds and fish and also currently sustains the livelihoods of many villagers (see Livelihoods report). Further encroachment into the Elephant Marsh and further transformation of vegetation habitats, for subsistence or commercial agriculture, will reduce the ability of the Elephant Marsh to sustain the current level of ecosystem goods and services being supplied and will put pressure on the livelihoods of the current population of local villagers.

**Table 16. Aquatic ecosystems in Malawi with similar vegetation habitats.**

| Name | Location | Area (ha) | Vegetation habitats present | Status (1992) |
|---|---|---|---|---|
| Marshes of Ruwenya Hills | Northwest Malawi | >1000 | Grass and reed swamps. | Unprotected |
| Marshes of Fort Hill Plain | South of Ruwenya Hills | 10 000 | Woodland and marshes. | Unprotected |
| Wetlands of the South Rukuru River | Western Zambian border | | Marshes. | Nyika National Park |
| Vwaza Marsh | South of Katumbi, Lewewe River | 40 000 | Marshes, reed/grass/sedge swamps, seasonal floodplain, dambos, riparian swamp, grassland. | Vwaza Marsh Game Reserve |
| Marshes of Kasungu Plain & the Bua River | Kasungu Plain | >10 000 | Grassy swamps, floodplain, marshes, dambos, riparian swamps. | Kasungu National Park, Nkhotakota Game Reserve |
| Marshes of the Lilongwe Plain | Lilongwe Plain | >35 000 | Woodlands and marshes. | Unprotected |
| Karonga Lakeshore Plain | Lake Malawi | | Swamps, dambos and marshes. | Unprotected |
| Limpasa Dambo | Nkhata Bay, Lake Malawi | 13 000 | Dambo. | Unprotected |
| Nkhotakota Lakeshore Lowlands | Lake Malawi | 20 000 | Unaka Lagoon, Bana Swamp, Dzedza Swamp, various marshes. | Unprotected |
| Salima Lakeshore Plain | Lake Malawi | 16 500 | Marshes and the swampy delta of the Lilongwe River. | Unprotected |
| Lake Molombe | Middle Shire River | 30 000 | Marshes, riparian and floodplain vegetation, gallery forest. | Liwonde National Park |
| Elephant Marsh | Chikwawa | 57 000 | Swampland, lakes, floodplain. | Unprotected |
| Ndinde Marsh | Nsanje | 20 000 | Swampland, lakes, floodplain. | Unprotected |
| Lake Chilwa | Liwonde | 185 000 | *Tyhpa* swamp and sedge marsh, grassy floodplain, lake. | Ramsar |

The most commonly-encountered exotic aquatic species was water lettuce *Pistia stratioites* (Table 10) while water hyacinth *Eichhornia crassipes,* red water fern *Azolla filiculoides* and Kariba weed *Salvinia molesta* were encountered much less frequently. These four species were found in the lake habitats, which were dominated by indigenous white lotus and hornwort. Non-aquatic pest species encountered, again infrequently, where the giant sensitive tree *Mimosa pigra* and honey mesquite *Prospis glandulosa.* The rest of the exotic species encountered (see Appendices to this report) were disturbance adapted perennials, annuals, or forbs, commonly encountered where humans inhabit and cultivate crops, and many of them are planted aside the crops for a variety of medicinal and herbal uses.

None of the study sites visited was under severe infestation by any of the exotic species encountered. The most likely to increase in extent would be the water lettuce, so monitoring the populations of this species would be wise.

## 2.4 Present status of habitats and plant species composition

In order to estimate the present condition of the Elephant Marsh in terms of its vegetative habitats and plant life, it is necessary to understand the factors that shape the main plant communities that might have changed over time, as well as drawing on any historical descriptions of the marsh and these driving factors.

### 2.4.1 Functionally distinct vegetation communities

The plant species composition of the lakes and the floodplain were different from the river channels and marsh. However there were no significant species composition or abundance differences between river banks (cultivated and uncultivated) and marsh. This was largely because of the dominance of common reed, papyrus and hippo grass*,* and the presence of floating aquatics red water fern and water lettuce*,* at or on most bank edges (marsh and rivers)*.* These similarities notwithstanding the floodplain and marsh (represented by permanently inundated sudd (floating papyrus) were mapped separately (see Hydromorphology report). As a consequence, the marsh was the most abundant habitat present in the Elephant Marsh. The other major habitats were river channel, floodplain and lakes.

### 2.4.2 Historical evidence

The Shire River channel meanders broadly before entering the anastomosing channels and distributaries of the eastern and central marsh. The channels are *c*. rectangular in cross-section, vary in width and depth at different points, and are stabilised by common reed, papyrus ad hippo grass (McCarthy *et al.* 1991). Flow through some channels discharges into marsh or lakes directly while some lakes are only connected to channels during the wet season. Flow also moves from the channels into the marsh through the permeable channel margins, comprised of decomposed plant material. Bedload sediments are confined within the channels but suspended sediments are transmitted through the channel banks into the marsh areas (McCarthy *et al.* 1991).

As with other floodplain wetlands, sedimentation causes constant change in wetland structure as channels aggrade and scour in response to changes in flow and sediment regimes (Rogers *et al*. 1995). Sedimentation processes may lead to a decline in flow velocity through direct channel aggradation (McCarthy *et al.* 1987), which may then be accompanied by secondary encroachment of papyrus from the channel margins into the channel. Encroaching papyrus rhizomes, culms and umbels further constrict the channel, forming a tangled debris mat (called a sudd) that breaks off and floats into the channel (Ellery *et al.* 1990). The growth of hippo grass is favoured in this situation and further constricts the channel, thus trapping debris mats and further enabling papyrus encroachment (McCarthy 1992). A debris dam may form that diverts flow beneath the blockage, scouring a new depression in the channel bed that will increase flow to the surrounding marsh around the failing channel, or into hippo trails that become enlarged and form new channels (Ellery *et al.* 2005).

This constantly changing mosaic of wetland habitats is typical of floodplain wetlands and means there is not a temporally-fixed "template" over a reasonable (for data collection) time period, for a marsh of this sort. Effectively, the only constant is change, and this was illustrated by the Ruo Rivers channel avulsion during the floods of January 2015.

In recent history, the Shire River used to flow closer along the western edge of the Elephant Marsh (blue, Figure 11) and the Namichimba tributary branched off at the northern end (green, Figure 11, near pollen core Site 1) splitting into many distributaries that reformed and split again through the marsh before flowing into the lake south of Muona.

In the 1980s, the historical course of the Shire River was purposefully narrowed and blocked to reduce the incidence of crocodile attacks near the western-edge towns and to facilitate cultivation of Nsua Island. This diversion of the Shire River reduced the flooding of marsh and floodplain habitat along the western edge and facilitated an extension of cultivation into these areas.

Today, the Elephant Marsh as a whole comprises: the Shire River (dark blue, Figure 11) which flows through the centre of the marsh; some distributaries in the northern end (orange) that are characterised by papyrus sudds (green) and that reform again as tributaries draining the southern portion back into the Shire River. There are also a few small permanently-inundated lakes (dark blue) in the northern portion and larger lakes located in the South.

The change in the extent of marsh and floodplain habitat notwithstanding, it is likely that the composition of dominant species has been fairly constant. The three most common marsh species, common reed, papyrus and hippo grass, are fairly resilient to clearing and sprout rapidly and more densely in response to being cut or burnt. Similarly, the non-woody species composition of the floodplain has probably not changed much although there may have been a greater abundance and diversity of woody plant species prior to cultivation. Floodplain woody plant species composition depends upon the inundation period and substratum type with rarely flooded areas often supporting good tree growth of Senegal date palm *Phoenix reclinata,* buffalo thorn *Ziziphus mucronata* and bastard marula *Lannea schweinfurthii,* often on termitaria (Timberlake 2000a).

The greatest change in vegetation species composition and abundance has taken place on river banks, in particular along the main stem of the Shire River. Most of the river banks would have been populated tall and dense riparian woodland comprised on large trees such as winter thorn *Faidherbia ablida*, Natal mahogany *Trichelia emetica*, *Acacia* spp. and waterberry *Syzigium* spp. (Table 17). Other woodland communities, such as Munga, Miombo and Mopane, would no doubt have occurred around the marsh fringe seasonally inundated floodplain. Baobab trees still occur around the marsh indicating where Mopane woodland would have occurred.

As is the case elsewhere in Africa, riparian woodland is now rare as a result of clearing for agriculture or over-harvesting for building materials and firewood/charcoal. Riparian woodland is an important habitat for wildlife and creates a corridor that protects river banks against erosion. Thus, conservation and economic value of remaining patches of the riparian forest in the Elephant Marsh is high even although the individual species are fairly widespread elsewhere.

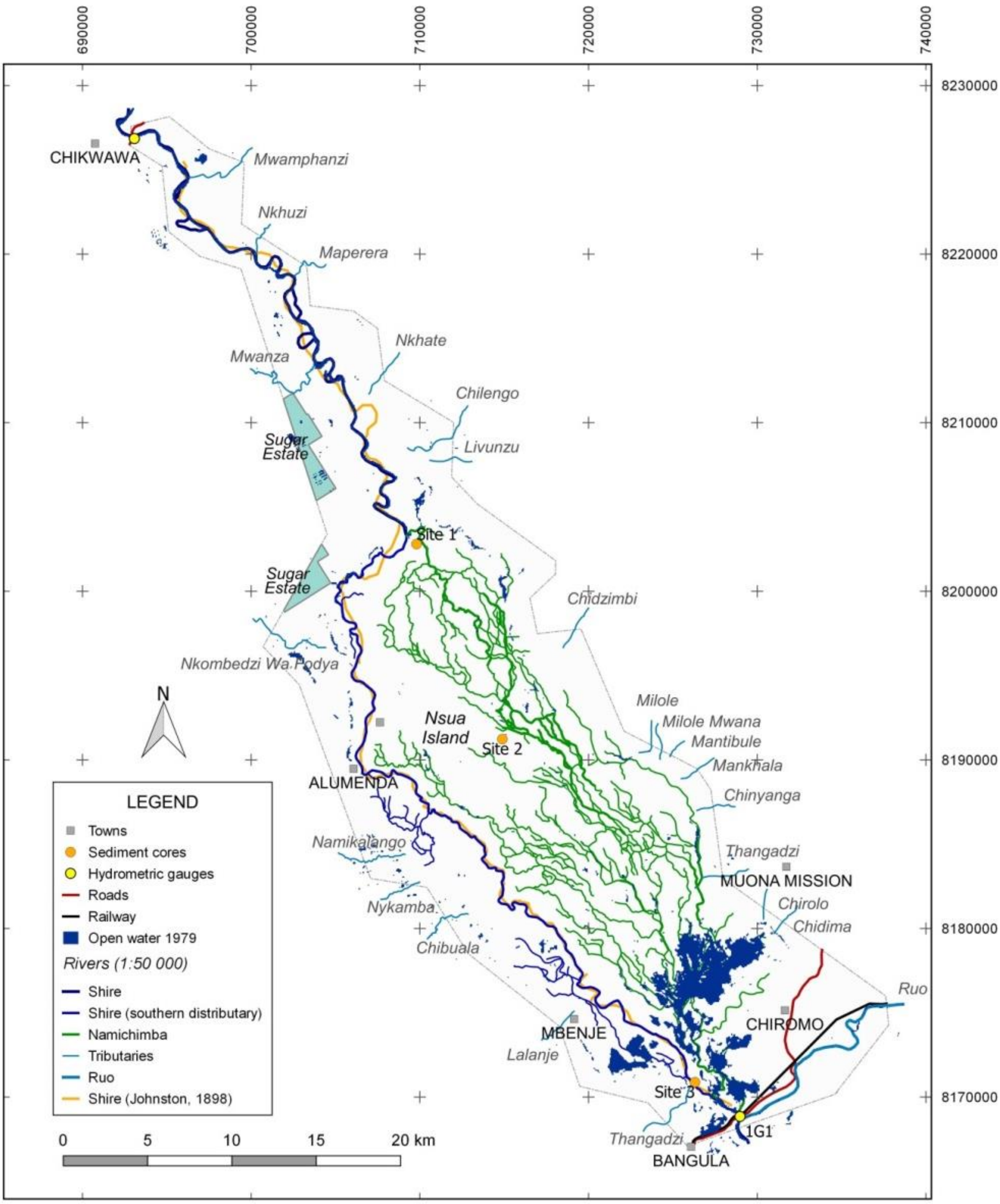


**Figure 11. An example of some of the mapping for the Elephant Marsh, indicating the area of interest (taken from the January 2015 floods) between Chikwawa and Chiromo Bridge; selected towns; main roads and railway line (not all presently passable); hydrometric gauges; large open water surfaces (lakes) mapped using 1979 Landsat multispectral imagery; rivers digitised from 1:50 000 topographical maps supplied by the Department of Surveys, Malawi (aerial photography between 1950 and 1977); sites where sediment cores have been extracted for carbon dating and pollen analyses; the Shire River as mapped by Johnston in 1898.**

**Table 17. Tree species typically found in African riparian woodland (Timberlake 2000b, Cunliffe 2002).**

| Community | Species |
|---|---|
| Marginal species | *Faidherbia albida* |
| | *Syzygium* spp. |
| | *Mimosa pigra* |
| | *Ficus sycamorus* |
| | *Ficus capreifolia* |
| Non-marginal species | *Kigelia africana* |
| | *Trichelia emetica* |
| | *Nuxia oppositfolia* |
| | *Rhus quartiniana* |
| | *Acacia robusta* |
| | *Acacia tortlilis* |
| | *Combretum imberbe* |
| | *Philenoptera violacea* |
| | *Tamarindus indicus* |

### 2.4.3 Present status of vegetation

The 2015 condition of the Elephant Marsh vegetation – based on its historic extent - was estimated to be in a D category (Kleynhans *et al.* 2007; Table 2), meaning that is was largely modified from the historically natural condition and/or associated with a large loss of habitat, biota and basic ecosystem functioning.

The reasons for the relatively poor condition of the marsh the extensive cultivation and consequent reduction in the extent of the marsh, the diversion of the Shire River main stem and the almost complete removal of woody plant. It is likely that the regulation of flow at upstream impoundments and elevated suspended sediment loads due to erosion in the upstream catchment have also contributed to the decline in ecological condition of the marsh.

The ecological condition of the current extent of the marsh (i.e. excluding the cultivated, inhabited and the infrequently inundated cleared woodland areas) was estimated to be in a C category, meaning it is moderately modified from the historical condition and/or associated with a loss or change in natural habitat and biota but that basic ecosystem functions persist.

# 3 AQUATIC INVERTEBRATES

## 3.1 Introduction

Aquatic macro-invertebrates are used worldwide as indicators of riverine condition (Metcalfe-Smith 1996), responding to immediate and long term changes in catchment hydrology, geomorphology and physico-chemistry. The objective of the macro-invertebrate study was to determine the present day ecological status of the Elephant Marsh and some of the main tributaries in its immediate vicinity. The study was based on a literature review and limited field sampling during a five day survey carried out from 17 to 21 January 2016.

## 3.2 Available information on macro-invertebrates

Based on the literature review, a list of expected taxa was compiled Appendix 2B. The groups currently best covered in literature for the region in terms of aquatic macro-invertebrates are:

- Mollusca;
- Coleoptera;
- Diptera: Simuliidae
- Trichoptera, and;
- Adult Odonata.

The information available on aquatic ecosystems in the Elephant Marsh is very scarce (Timberlake 2000a), and most of the data collected from literature that are included in Appendix 2B came from the Guides to Freshwater Invertebrates of Southern Africa (Appelton 1996, Appleton 2002, Barber-James & Ludo-Oritz 2003, Briström 2007, Coetzee 2002, De Moor & Scott 2003, Dijkstra & Clausnitzer 2014, Drumont 2001, Endrödy-Younga & Stals 2007, Harrison *et al.* 2003, Hart *et al.* 2001, Kensley 2001, Reavell 2003, Stals 2007, Stals & Endrödy-Younga 2007, Van Hoven & Day 2002), and includes all of Malawi, not only the Elephant Marsh. In a separate study where light traps were used, seven new species of adult *Chimarra* (Trichoptera: Philopotamidae) have recently been discovered (Wahlberg *et al.* 2014). The elevations at which they were recorded ranged from 870 to 2240 m a.m.s.l., while elevations in this study area range from 80 to 100 m a.m.s.l. The Wahlberg survey does state that more work focusing on arthropods of the region is required.

## 3.3 Field survey methods

Rivers flowing into the Elephant Marsh from the western mountain slopes were sampled to determine their ecological health before they flow into the Marsh, and two areas on the Shire River in the Elephant Marsh, and a lake were sampled (Figure 12). The lake was linked to the Shire River, but was not affected by the turbid waters of the Shire during the sampling period.

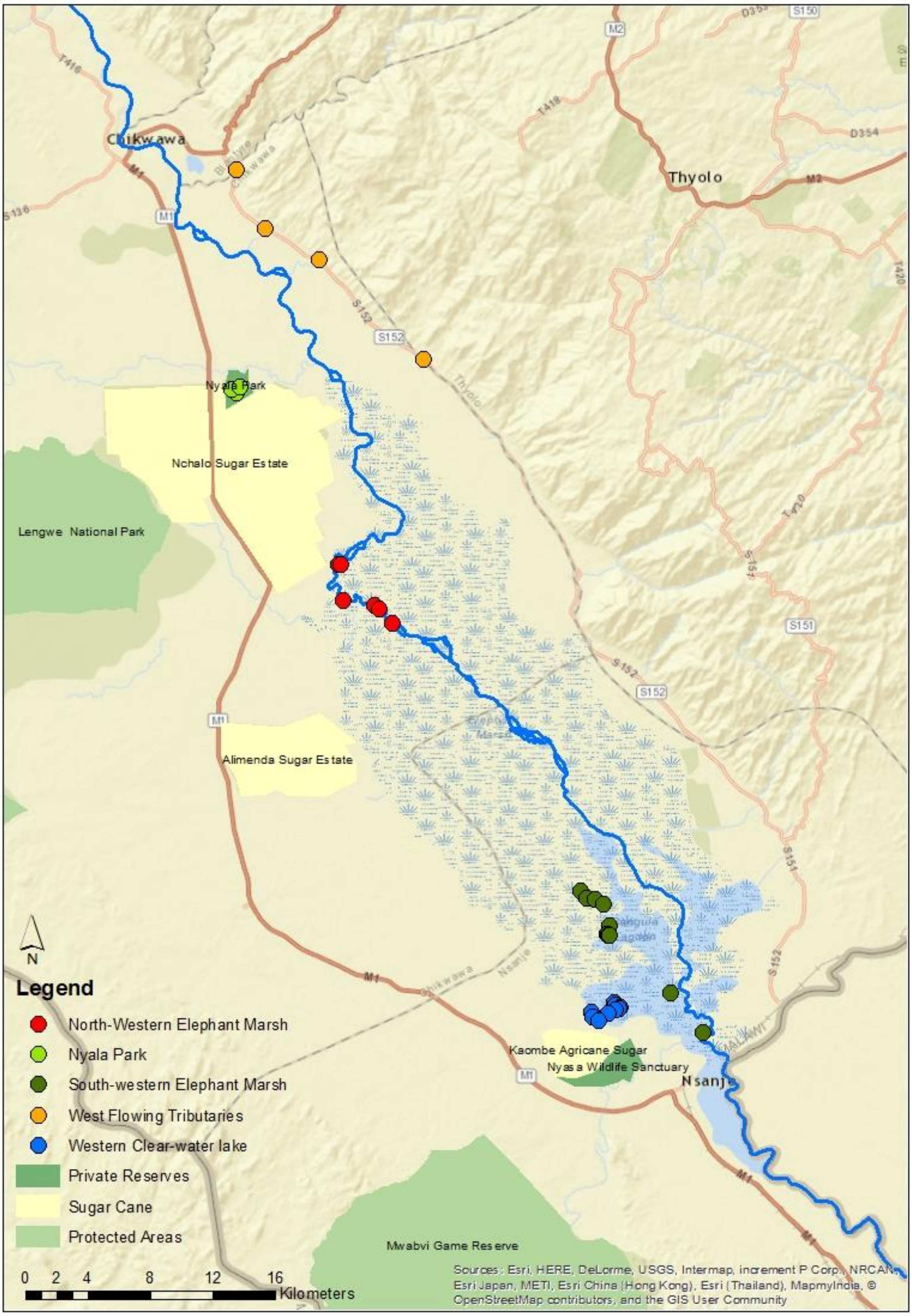


**Figure 12. Aquatic Invertebrate Sampling sites across the study area.**

For each site, the catchment and instream habitat was assessed, and in situ measurements of physical and chemical water quality variables were carried out. Aquatic macro-invertebrates were sampled using the standard South African Scoring System, version 5 (SASS5).

Note that Odonata adults were surveyed in more detail by Klaas-Douwe Dijkstra (KD) in March 2016, and are discussed in more detail in Chapter 4. Notes of Odonata nymphs encountered in this January 2016 survey are also included in Chapter 4.

### 3.3.1 Water Quality

At each site, water temperature, pH, and conductivity was measured using a Eutech Cyberscan PC10 water quality meter, and dissolved oxygen (concentration in mg/ℓ and % saturation) was measured using an AZ8403 dissolved oxygen meter. Water clarity was measured with a 120 cm turbidity tube. Results were compared against the water quality guidelines for aquatic ecosystems in South Africa (DWAF 1996).

### 3.3.2 Habitat Assessment

The habitat assessment rated catchment condition, which could affect instream habitat conditions and in turn the biota, through the evaluation of local and upstream catchment conditions (Appendix 2A).

### 3.3.3 Aquatic Macro-invertebrate assessment

Taxa were sampled in the different biotopes with a standard SASS kick-net (32 x 32 cm x depth 40 cm, and mesh size 1 $mm^2$), emptied into a tray, identified to family level. Taxa which looked like different species were collected for further identification using the following available field guides[5] on aquatic macro-invertebrates:

- Coleoptera (Briström 2007, Endrödy-Younga & Stals 2007, Stals 2007; Stals & Endrödy-Younga 2007);
- Crustaceae (Hart *et al.* 2001, Kensley 2001);
- Diptera (Coetzee 2002, Harrison *et al.* 2003);
- Ephemeroptera[6] (Barber-James & Ludo-Oritz 2003);
- Hemiptera (Reavell 2003);
- Hirudinea (Oosthuizen & Siddal 2002);
- Mollusca (Appelton 1996, Appleton 2002);

[5] The crabs, Potamonautes obesus, was identified from specimens collected in reptile traps by Prof S. Daniels from the University of Stellenbosch.

[6] Genus identification of Oligoneuridae (*Elassoneuria* sp.) and Polymitarcidae (*Ephron* sp.) was confirmed by Dr H. James from Albany Museum, Grahamstown.

- Odonata[7] (Dijkstra & Clausnitzer 2014, Samways 2008, Suhling *et al.* 2014, Tarboton & Tarboton 2015);
- Oligochaeta (Van Hoven & Day 2002); and
- Trichoptera (De Moor & Scott 2003).

#### 3.3.3.1 Wadeable rivers (SASS5)

Aquatic macro-invertebrates were collected in wadeable rivers using the SASS5 method (Dickens & Graham 2002). Taxa were collected in three different biotopes (stones, vegetation and gravel/sand/mud) which were present at each site.

The community composition combined with instream habitat types sampled were used to determine whether current conditions are related to water quality, instream habitat or flow (Thirion 2008).

Since taxon abundance affects community composition, the abundance was rated using the approach in Chessman (2003) to determine percentage of sensitive taxa and an adjusted average score per taxon (ASPT).

The pollution sensitive index (PSI) was also calculated incorporating taxon abundances. The PSI is based on the tolerance or/and sensitivity of the taxon to sedimentation (Extence *et al.* 2013).

The Lotic Invertebrate Index for Flow Evaluation (LIFE) was also calculated. This is similar to the PSI, but based on flow condition preference of the invertebrate community encountered (Extence *et al.* 1999; Dunbar *et al.* 2009).

Functional feeding groups (FFG) or taxa trophic relationships were assigned based on (Merrit & Cummins 1996; Cummins *et al.* 2005). Here the morpho-behavioural mechanisms of food acquisition is classified into FFG's, which includes shredders (Sh), scrapers (Sc), predators (Pr), piercers (Pi), and gathering (Gc) and filtering collectors (Fc). Dominance of a FFG indicates dominant food source during the survey, with, for example Gc's indicating course particulate organic matter as the main food source, and Fc's fine particulate organic matter.

#### 3.3.3.2 Non-wadeable aquatic systems

Invertebrates were sampled and collected in marginal vegetation differing in structure and flow categories to sample the different preferences of taxa residing in this biotope. Mud-banks, sand and depositional biotopes were sampled where they were accessible (<1 m deep). Taxa collected were identified to family, genus or species level. Data collected from a specific area was assimilated to determine community composition within the sampled biotopes for that area (e.g. for sites in the north-western Elephant Marsh). Community composition was established using the sensitivity index from SASS5, PSI, LIFE and FFG dominance as indicators.

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[7] Most of the adult Odonata was identified by Dr. KD Dijkstra (see section 4 of this report).

Data from the Shire River's westward-flowing tributaries and the Shire River itself are presented separately. This is because the SASS method can only be applied to wadeable rivers.

### 3.3.4 Data interpretation

Current conditions were compared to those expected under natural (no anthropogenic influences) conditions. Where information or data were lacking, the current understanding and guidance of ecological principles and concepts based on scientific literature was applied.

With a lack of available data, the SASS5 results for wadeable rivers (four sites) were compared against the biological bands defined in Dallas (2007). These were determined, based on existing data for sites located within the Lowveld Aquatic Ecoregion. The ecoregion is mainly granite savanna between elevations of 0 – 700 m a.m.s.l. (Kleynhans *et al.* 2005).

In the application of the PSI, the community dominance in terms of sedimentation is categorised as unsedimented, slightly sedimented, moderately sedimented, sedimented and heavily sedimented.

In the application of LIFE, community composition is categorised as preference to very fast flows, fast, moderate, slow, stagnant and drought resistant.

The FFG just identified the most dominant group present. Overall conditions are presented as a class, which is a comparison to expected natural conditions (Table 2).

A list with detailed information of sites sampled, indicating the area in which they were sampled, the date, river or system, GPS co-ordinates and elevation range is presented in, with up- and downstream photos of wadeable streams, and habitat photos of other systems are included in Appendix 2A.

## 3.4 Limitations of the study

### 3.4.1 Reference conditions unknown

The composition of aquatic biota and the condition of the water bodies in the Study Area prior to anthropogenic impacts will never be known for certain because of the lack of historical reference data prior to such disturbance. The data interpretation for reference conditions are therefore very broadly defined based on results for similar areas and existing knowledge of habitat preferences of specific taxa.

### 3.4.2 Species identification

With most of the taxa encountered, identification to species level cannot be made with confidence. The level of confidence with identification within most of the orders (excluding adult Odonata, which are described in more detail in the next chapter) are only to genus level. This is attributed to a lack of current and historical detailed surveys of African species, with very limited literature such as dichotomous keys and ecological information about the species.

### 3.4.3 Limited sampling

In the westward-flowing tributaries of the Shire River, the maximum river length sampled at a site was 100 m, in a catchment draining several kilometres of river in a large catchment area. The sampling event is therefore a brief window of the present conditions of a river at a specific site in time and space. Spatial and temporal variation, and natural and anthropogenic influences were not incorporated into this assessment. Several data sets which incorporate seasonality and changes over time are required to properly understand current conditions. Caution is therefore needed when interpreting biomonitoring data while continuous monitoring will assist in broadening the data base and providing for more meaningful interpretation.

In the main Shire River, only shallow marginal vegetation and mud banks accessible with a small boat were sampled. No sampling was carried out in the deeper sections of the wetland (>1 m), which represent a large portion of the study area. To sample these habitats, specialised equipment (e.g. large steady boat to use a bottom sampling dredge, Dendy larval samplers, terrestrial and aquatic light traps) and additional field time is required.

When sampling was carried out in the north-western portion of the Elephant Marsh, there were mechanical problems with the boat which reduced sampling time and coverage.

## 3.5 Habitat descriptions

Brief descriptions of habitats sampled are given below. Detailed summaries of habitat features are included in Appendix 2A. The sites on the west-flowing tributaries of the Shire River are all upstream from the sites sampled in the north-western (NEM), south-western (SEM) and western portion (WEM) of the Elephant Marsh.

### 3.5.1 Physical habitat

#### *3.5.1.1 Nyala Park*

Impoundments at the picnic site are fed by pumped groundwater as well as groundwater seepage. These impoundments divert water into earth canals which are regularly excavated to deepen them, remove vegetation and to improve flow. The endopheric depression was the only natural feature in the Nyala Park.

#### *3.5.1.2 West flowing Shire River tributaries*

The four river sites were very similar during the January 2016 site visit, characterised by extremely high sedimentation, red-brown water colour with extremely high turbidity, bank scouring, sediment movement and deposition, presence of cobble-boulder, gravel sand and vegetation biotopes. Bare stream banks were more common than vegetated banks. The hydraulic biotopes present at all of the sites were riffles, runs, glides and pools. Rapids were only present at one of the sites.

#### *3.5.1.3 Shire River - Elephant Marsh*

The Shire River is meandering in the NEM and braided-meandering in the SEM. The meandering and braided channels are a characteristic of lowland rivers on gentle slopes, exposed to erosion and decomposition and exaggerated meandering over time (Smith & Stopp 1978). Erosion is generally more prevalent at the outside edges of these meandering curves, with deposition on the inside of the curve (Figure 13). The deposition of materials then leads to the creation of a seasonally inundated floodplain, radically increasing aquatic habitat heterogeneity. Naiman *et al.* (1993) summarised literature pertaining to the importance of riparian corridors, and indicated that the physical heterogeneity of such floodplains alters biological responses to flooding, and the riparian and terrestrial habitats and hence the ecology of rivers.

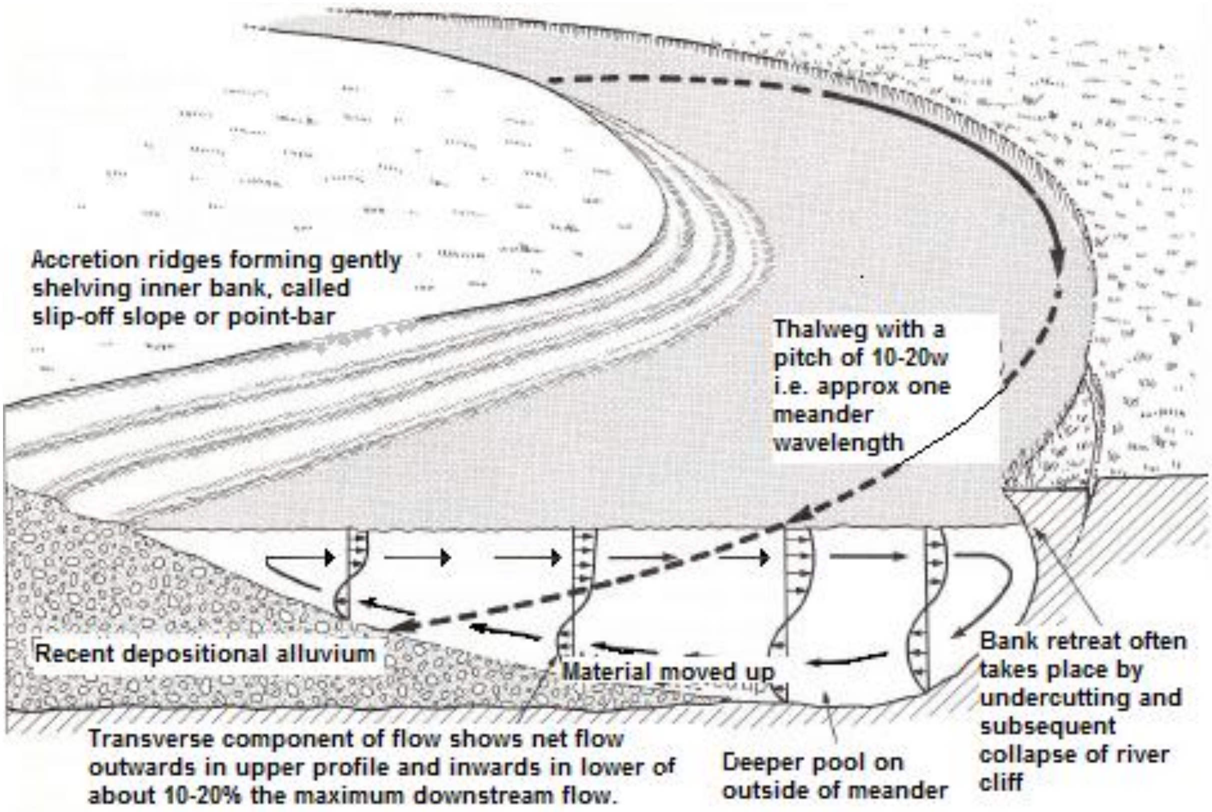


**Figure 13. An illustration copied from Smith & Stopp (1978), indicating the processes creating channel features.**

Sites sampled in the NEM portion were located in marginal vegetation that had different plant species composition, flow velocities, as well as mud and sand banks. Vegetation biotopes were dominated by reeds *Phragmites* sp. and hippo-grasses *Vossia cuspidate*, and to a lesser extent water lettuce *Pistia*, water fern *Azolla*, and water hyacinth *Eichhornia* species. The main river channel is sinuous, deep and relatively fast flowing, with eroded and vegetated banks, as well as backwaters. The water turbidity was extremely high, water clarity 2 cm, and the water colour red-brown.

The habitat in the southern portion of the Elephant Marsh differed from the NEM potion in terms of marginal vegetation, and also a slight improvement in water clarity. The river is channel is wide, sinuous and deep, with fast flow water in the mid-channel and low flowing backwaters through aquatic vegetation. Dominant marginal vegetation sampled included water spinach *Ipomoea aquatica*, hippo-grass *Vossia cuspidate*, reeds *Phragmites australis*, and papyrus *Cyperus papyrus,* with water lettuce *Pistia*, water fern *Azolla*, and water hyacinth *Eichhornia* species also present.

#### 3.5.1.4 Western clear water lake – Elephant Marsh

This is a very slow flowing body of water in a depression in the ground forming a natural impoundment of water, and will be referred to as a ***lake*** hereafter, since it fits the definition most closely. This lake is characterised by clear stagnant water, with a high abundance of aquatic plant growth in the water column and along the edges of the water body. A very high number and diversity of water birds was also noted at this site. The lake is directly linked to the Shire River, and the one site (SEM-07) was located at the edge of the Shire River where the clear water from the lake and turbid waters from the Shire River meet. Water clarity measured at the WEM sites was >120 cm, with no visible flow. Dominant marginal and aquatic vegetation included hornwort *Ceratophyllum demersum*, lotus water lilies *Nymphaea lotus*, water spinach *Ipomoea aquatica*, creeping ludwigia *Ludwigia stolonifera*, hippo-grass *Vossia cuspidata*, papyrus *Cyperus papyrus* and reeds *Phragmites australis*.

### 3.5.2 Water quality

A summary of water quality variables measured per tributary site (RV), and combined results for the NEM, WEM and SEM sites are presented in Table 18 below.

**Table 18. Results of in situ water quality parameters measured in January 2016.**

| Sites | Area/river | Time | Temperature | pH | Electrical Conductivity | Dissolved Oxygen | | Water Clarity |
|---|---|---|---|---|---|---|---|---|
| | | | °C | | ∓S/cm | mg/ℓ | % | cm |
| RV-01 | Mwamphanzi | 16:00 | 30.4 | 8.1 | 195.0 | 3.6 | 54.9 | 2 |
| RV-02 | Nkhuzi | 17:35 | 28.6 | 8.2 | 320.0 | 3.3 | 47.7 | 3 |
| RV-03 | Maperera | 12:25 | 27.8 | 7.8 | 145.8 | 3.7 | 52.3 | 2 |
| RV-04 | Limphangwi | 16:15 | 30.9 | 8.0 | 188.0 | 3.8 | 56.8 | 3 |
| NEM | North-western marshes | | 27.5-28.4 | 7.6-7.8 | 211-219 | 2.4-3.0 | 34.3-42.0 | 2 |
| WEM | Western clear-water lake | | 30.8 | 8.7 | 295 | 9.4 | 145.5 | >120 |
| SEM | South-western marshes | | 27.3-29.7 | 6.7-7.5 | 244-286 | 0.7-4.5 | 9.8-66.1 | 5-130 |

Water temperature measured in the study area ranged from 27 to 31°C, while pH was between 6.7 and 8.2. The highest pH value was measured in the Western Clear-water Lake, followed by the sites located in the four west-flowing tributaries (7.8 to 8.2). In the Shire River itself, pH values measured ranged from 6.7 to 7.8. Electrical conductivity (EC) was the highest in the Nkhuzi River, followed by the Western Clear-water Lake. The lowest EC was measured in the Maperera River, while the EC measured at sites located in the NEM was slightly lower than those in the SEM portions. Dissolved oxygen was the highest in the WEM Clear-water Lake (145.5%) and the lowest in the SEM portions. Overall dissolved oxygen levels measured were very low. Water Clarity was extremely low in the wadaeble river sites (RV) and in the Elephant Marsh at the NEM sites, ranging between 2 and 3 cm. Water clarity improved slightly in the Elephant Marsh at site in the SEM, ranging from 5 to 130 cm. The highest water clarity was measured at the WEM sites, which were all >120 cm.

## 3.6 Present day biota and community composition

Present day biota and community composition, ecological and conservation significance, and the main abiotic and/or biotic drivers determining the abundance of taxonomic groups or key species are discussed for the three regions sampled, namely the west flowing tributaries, NEM, SEM and WEM clear-water lake.

A total of 77 taxa (excluding adult Odonata) were recorded in the study area, of which most were identified to genus, family, and where confidence was high, species level. A list of taxa recorded in the different sampling areas and in the west-flowing tributaries is included in Appendix 2B. A summary of the SASS5 results for the west-flowing tributaries of the Shire River is included in Table 19, and the cumulative data of biota composition at sites located in the north-western, south-western and western portions of the Elephant Marsh is included in Table 20. For a full list of Odonata recorded in the study area refer to Chapter 4 of this report.

### 3.6.1 Taxonomic diversity

A list of taxa recorded at the different sampling points is included as Appendix 2B, with a summary of taxa (excluding Odonata) recorded in Malawi and in the different areas sampled in 2016.

Taxonomic diversity was very low in sites located on the four of the westward-flowing tributaries. It is likely that that there are still refuge habitat for species in some of the upper tributaries in these systems. If so, these refugia would be critically important for system recovery once sources of deterioration are addressed.

Species diversity in the Elephant Marsh increases downstream, as habitat heterogeneity increases (e.g. widened river channel, variation in water velocity and depth). Species richness in tropical aquatic ecosystems generally increased towards lower elevations, attributed to this general increase in habitat heterogeneity. The species occurring in these areas are generally warm-adapted Afrotropical fauna which are typically tolerant to such changes in habitat (increased heterogeneity).

### 3.6.2 West-flowing tributaries

The SASS5 results for the four wadeable river sites are summarised in Table 19. Taxonomic diversity in the westward-flowing tributaries was extremely low (# Fam., Table 19), with taxa considered tolerant to disturbances being dominant (AASPT, Table 19). The stream community had a high component of air breathers (%AB), with the highest percentage (83%) recorded in the Maperera River. The PSI indicated a dominance of taxa tolerant to heavy sedimentation in three of the river sites. In general for all sites, taxa with a preference for slow flowing conditions dominated, with cobble biotopes present but low in taxonomic diversity and abundance.

**Table 19. A summary of the SASS5 results for sites located on wadeable rivers, indicating total SASS score (Score), the number of families (# Fam), the average score per taxon (ASPT), the adjusted ASPT (AASPT[8])number of taxa, the percentage of community represented by air breathers (%AB), the percentage of sensitive taxa (%ST) based on SASS5 taxa index ratings, the rated pollution sensitive index to sedimentation (PSI), the dominant flow preference, and the dominant functional feeding group (DFFG) represented in the samples.**

| Site | River | SASS5 | | | | | | PSI | DFFG | LIFE |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Score | # Fam | ASPT | AASPT | %AB | % ST | | | |
| RV-01 | Mwamphanzi | 51 | 10 | 5.1 | 4.6 | 64 | 4 | HSed | Pr | Slow |
| RV-02 | Nkhuzi | 40 | 8 | 5.0 | 5.2 | 60 | 26 | Sed | Pr | Slow |
| RV-03 | Maperera | 43 | 10 | 4.3 | 4.8 | 83 | 35 | HSed | Pr | Slow |
| RV-04 | Limphangwi | 43 | 10 | 4.3 | 4.6 | 59 | 0 | HSed | Pr | Slow |

Taxonomic diversity at in all four rivers sampled was extremely low (Table 19). The lowest diversity overall was recorded in the stones and the sand-mud-gravel biotopes, while the highest was recorded in the marginal and aquatic vegetation biotopes. This is despite the presence of rapid-riffle-run hydraulic biotopes with cobble-boulder substrates, where the highest diversity of taxa are usually expected. The marginal vegetation biotope was also poorly represented at most of the river (RV) sites (Appendix 2A), mainly as a result of low flow, high sediment deposition and bank scouring.

Flow sensitive species were recorded at low very low numbers, while taxa with a preference for slow flows (0.3 to <0.1 m/s) dominant at all four river sites. This taxa flow preference was evident in LIFE scores, listed in Table 19.

Taxa with a tolerance for high sedimentation were dominant at all four the river sites (Table 19). High sediment movement and deposition was evident at all four the sampling sites. The state of these rivers is attributed to poor catchment management, exacerbated by a lack of road drainage and poorly designed river crossings.

Predators were the dominant FFG represented at all four the wadeable river sites at the time of the sample, suggesting abnormal predator-prey top-down control. This is often characteristic of disturbed sites where colonisation occurs.

[8] The AASPT incorporates abundance ratings (based on SIGNAL 2 in Chessman (2003)) in an effort to determine community preferences.

### 3.6.3 Shire River and western lake

Samples were collected in the NEM and SEM, and from the WEM clear-water lake. Taxa were collected from different sampling points, covering different biotopes, and combined for each region to determine present health state (Table 20).

**Table 20. A summary of the number of taxa, the percentage of community represented by air breathers (%AB), the percentage of sensitive taxa (%ST) based on SASS5 taxa index ratings, the rated pollution sensitive index to sedimentation (PSI), the dominant flow preference, and the dominant functional feeding group (DFFG) represented in the samples. . Number of taxa refers to those included on the SASS5 data sheet (SASS taxa), whereas the Total taxa refers both SASS and non-SASS aquatic taxa recorded at the site.**

| Area | No. Taxa | Total taxa | %AB | %ST | PSI | LIFE | DFFG |
|---|---|---|---|---|---|---|---|
| NEM | 17 | 19 | 24 | 59 | Sed | Slow | Gc |
| SEM | 26 | 37 | 60 | 33 | Sed | Slow | Gc |
| WEM | 26 | 31 | 75 | 7 | HSed | Slow | Sc |

#### *3.6.3.1 Shire River – north-western (NEM) and south-western (SEM) portion*

Fewer taxa were recorded at sites sampled in the NEM than in the SEM, with an increase in the percentage air breathers from the northern to the southern portion (Table 20). The highest taxa diversity was recorded in the southern portion, especially in the ecotone between the clear and turbid waters (SEM-07). Taxa sensitivity to pollution (based on the SASS5 index) was present in the Shire River in both the NEM and SEM sampling areas. Sensitive Ephemeroptera (Mayflies) families were more diverse at the NEM than the SEM portion. The FFG represented by gathering collectors were generally more dominant in samples, keeping in mind that samples in the main Shire River were only collected in the vegetation and shallow sand-mud biotopes. In the Shire River, taxa diversity was relatively low in the NEM but increased considerably towards the SEM portions (Table 20). The highest overall diversity was recorded in the marginal and aquatic vegetation biotopes, which were also the most common biotopes sampled. The point locality with the highest diversity recorded in the entire system was on the ecotone between the clear and turbid waters (S16°29'3.94", E 35°4'39.79"), with large schools of small fish.

Flow sensitive species were recorded in very low numbers, while taxa with a preference for slow flows (0.3 to <0.1 m/s) dominated (Table 20). There was a shift in community composition in terms of flow preference between the NEM and SEM sites, with a downstream increase in numbers of taxa preferring slow to zero flows (Appendix 2C). This is attributed to the widening of the river channel in a downstream direction, associated with the increase in slow flowing habitats and aquatic vegetation out of current.

Taxa with a tolerance for high sedimentation were dominant (Table 20). High sediment movement and deposition was evident, with the water very turbid at most of the sampling locations.

Taxa considered sensitive to pollution were well represented at the sites located in the NEM, with a slight decrease in the SEM (Table 20). Sensitive taxa decreased in a downstream direction and tolerant taxa increased. Tolerant to highly tolerant taxa increased from 35% of the community at the NEM region to 67% in the SEM region (Appendix 2C). Sensitive taxa recorded at the NEM sites absent in downstream (SEM) samples included mainly the mayflies (Ephemeroptera) families Heptageniidae (*Afronus* sp.), Oligoneuridae (*Elassoneuria* sp.), and Polymitarcidae (*Ephron* sp.).

In terms of functional feeding groups, gathering collectors were the most dominant at sites sampled (Table 20) in the NEM and SEM regions of the Shire River (Appendix 2C). There was also an increase in scrapers, mostly in the form of Gastropods, associated with slower flowing aquatic vegetation habitats.

#### *3.6.3.2 Western clear-water lake (WEM)*

No flow was observed in the clear water lake in the WEM which was dominated by aquatic plants and a high diversity and abundance of bird life. The diversity of aquatic macro-invertebrates was relatively similar to that of the SEM portion of the Shire, but sensitive taxa were almost completely absent (ST% = 7, Table 20). Most of the taxa were air breathers (AB% = 75%). The most dominant FFG encountered were the scrapers (Sc) comprising predominantly Gastropods.

Samples were collected in riparian vegetation and mud at eight sampling locations in the clear-water lake, mostly in marginal, submerged aquatic vegetation (hornwort - *Ceratophyllum demersum*), and the shallow muddy edges.

Overall, tolerant taxa (93%) dominated (Appendix 2C), with sensitive taxa (7%) present. The sensitivity is more related to dissolved oxygen fluctuation than anthropogenic pollutants.

As indicated by the aquatic vegetation component in the system, the water is mainly stagnant, and this is reflected in the macroinvertebrate community recorded, with 91% of the taxa encountered preferring stagnant to slow flowing waters (Appendix 2C).

As expected, the functional feeding group in this portion of the system was dominated by scrapers (e.g. gastropods), which is related to the abundance of aquatic vegetation.

## 3.7 Ecological and conservation significance

Most taxa could only be identified to genus level. Some of the more sensitive taxa encountered were rare at sites sampled, and based on overall conditions of the catchment and rivers in the study area, these species might be rare, threatened and endangered on a local scale.

Taxa generally associated with floodplain systems are diverse, linked to the heterogeneity of the habitat and influenced by the changing environmental conditions linked to hydrological, geomorphological and physico-chemical variations. The changes in hydrology increase or decrease temporal habitats, and biota associated with these temporal changes are adapted to withstand harsh conditions. Many aquatic invertebrates associated with temporal habitats have adapted to these conditions with rapid development strategies (e.g. egg to adult), eggs oviposited into plant tissues or mud to survive desiccation, and obligatory migration (Suhling *et al.* 2006) to mention a few. These strategies ensure community composition shifts as water levels increase or decrease.

Also, species generally associated with these habitats are resilient. The ecological significance of the three main area sampled is described below.

#### 3.7.1.1 West flowing tributaries

In its current state, the rivers and some of the other tributaries in the area observed are sources of high sediment input into the Shire River. The high sediment movement, depostion and low water clarity in these tributaries reduce taxa diversity, as evident in the 2016 results. Tributaries generally increase habitat heterogeneity (Rice *et al.* 2001, Rice *et al.* 2006), therefore increasing catchment biological diversity (Rice *et al.* 2008, Sedell *et al.* 1990). The dominance of taxa in the vegetation biotope (despite its low availability), and the absence of taxa expected and usually associated with cobble-boulder substrate biotopes in rapid-riffle-run hydraulic biotopes suggests high levels of disturbance. Improving land management in the catchments of these tributaries will not only improve biodiversity for the region, but will reduce excessive sediment inputs into the system. Also, these tributaries will dilute polluted waters and improve conditions in the Elephant Marsh.

#### 3.7.1.2 Shire River

The Shire River is meandering in the NEM and braided-meandering in the SEM visited. The meandering and braided channels are a characteristic of lowland rivers on gentle slopes, exposed to erosion and decomposition and exaggerated meandering over time (Smith & Stopp 1978). Erosion is generally more prevalent at the outside edges of these meandering curves, with deposition on the inside of the curve (Figure 13). The deposition of materials then leads to the creation of a seasonally inundated floodplain, radically increasing aquatic habitat heterogeneity. Naiman *et al.* (1993) summarised literature pertaining to the importance of riparian corridors, and indicated that the physical heterogeneity of such floodplains alters biological responses to flooding, and the riparian and terrestrial habitats and hence the ecology of rivers.

The increase in taxonomic diversity at the SEM portion of the Shire River conforms with the trend discussed above. Current land-use impacts such as the upstream water damming and abstraction (Kamuzu, Tedzani and Nkhula Barrages), and the removal of riparian zones (e.g. agricultural crops & livestock) alters the systems hydrology, geomorphology and physico-chemical attributes, which can have serious implications for ecosystem functioning and biodiversity.

#### 3.7.1.3 Western clear-water Lake

The composition of biota recorded is typical of tropical stagnant waters or lentic systems. Large numbers of egg-shaped lanistes *Lanistes ovum* from the family Ampullariidae were recorded mainly where there were hornworts *Ceratophyllum demersum* and water lilies *Nymphaea lotus*.

High abundances were also noted on the rest or nesting sites of Openbill Storks *Anastomus lamelligerus* (Figure 14), suggesting *L. ovum* is an important food source for biota in the region. Scrapers are herbivores or grazers of mineral or organic surfaces, while the shredders assist decomposing bacteria in breaking down accumulated organic matter (Cummins *et al.* 2005; Merrit & Cummins 1996). Within the floodplain system, such stagnant water areas drastically increase aquatic habitat diversity by providing different conditions on a spacial and temporal scale. These conditions include clear lentic water which provides nursery areas and food sources for numerous biota, allow for aquatic plant growth, and allows for organic matter build up. When the system is flushed with the input of water, the environmental variables all change, which, in turn will alter the biota.

**Figure 14. Openbill Stork (*Anastomus lamelligerus*) in the western clear water Lake portion of the Elephant Marsh on the left, with the high amount of *Lanistes ovum* shells on its nest or resting site (Photos: G. Diedericks).**

### 3.7.2 Abiotic and biotic drivers, and key species

All aquatic ecosystems are driven by the hydrology, geomorphology and physico-chemical processes and their interactions. The biota (vegetation, fish, aquatic invertebrates, zooplankton, etc.) have evolved physiologically, morphologically and behaviourally over millions of years within these systems, and therefore respond to any changes in these abiotic factors.

#### *3.7.2.1 West flowing tributaries*

Malawi is considered as one of the world's least developed and most densely populated countries. It is estimated that the country's population density has grown from 85 people/km$^2$ in 1987 to 139 people/km$^2$ in 2008, with more than 80% of the population dependant on agriculture for an income. The increase in population size resulted in smaller landholdings, with increased pressure on arable land (Department of Population and Development 2011). There is now less natural vegetation in the catchment due to the establishment of crops and livestock grazing to feed a growing population.

The lack of catchment vegetation (Figure 16) brought on by land clearing decrease water infiltration rates, with increased run-off velocity (Figure 15) and hence erosion and transport rates to natural drainage lines. These increased levels of sediment inputs into rivers can raise the level of the river bed, especially at obstructions such as bridges (Figure 17 and Figure 18). This "raised" riverbed increase water levels, and with the increase in run-off and velocity due to a lack of filtration in the catchment, peak flows are increased. The result is bank and river bed scouring, and high downstream sediment delivery. The deposition upstream from flow obstructions is evident at all natural drainage channels in the study area ((Figure 17 and Figure 18).

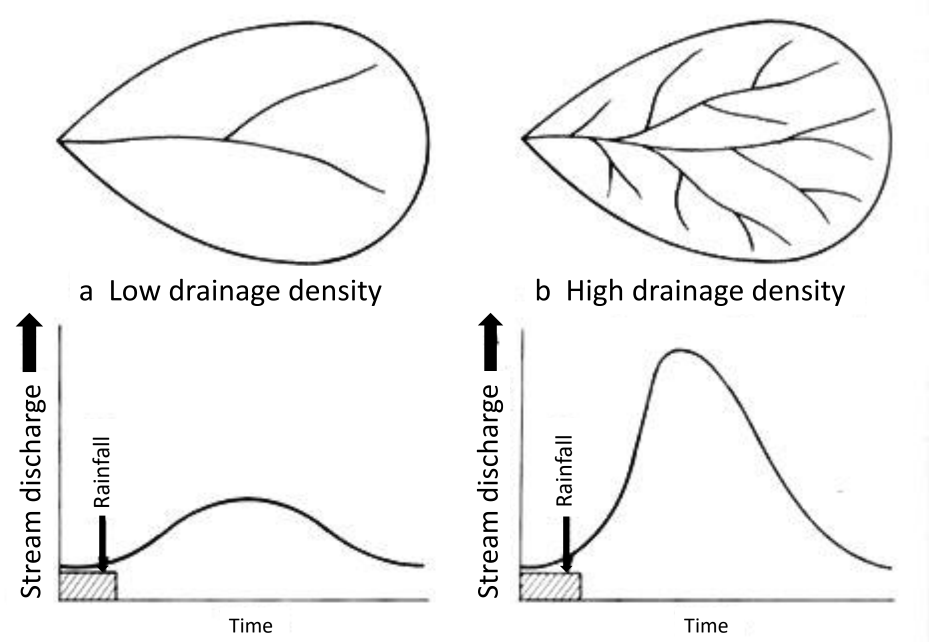


**Figure 15. Response in stream discharge after rain in a catchment where drainage density increased (Smith & Stopp 1978).**

**Figure 16. The lack of vegetative cover in the catchment of the west flowing tributaries of rivers sampled in the region is evident. The community is cultivating the mountain slopes, removing natural vegetation to establish crops (S16.17445 & E34.99253, 18 January 2016, G Diedericks).**


**Figure 17. High run-off and eroded soils end up in the rivers, clogging and accumulating at obstructions, and resulting in severe damage to infrastructure, the river bed and inevitably biota (S16.16474 & E34.98224, 18 January 2016, G Diedericks).**

**Figure 18. Agricultural activities in the riparian zone, with no riparian buffer zone is evident up- and downstream from the crossing. Eroded soil deposited into the stream deposits upstream from the crossing, and the "higher" water level during flood events increases erosive capacity, which is evident from the bank and bed scouring downstream from the crossing (S16°5'47.5" & E34°54'43.52", 18 January 2016, G Diedericks).**

#### *3.7.2.2 Lower Shire River*

Shela (2002) reported that the Shire River up to 1903 was the link between Malawi and the ocean in terms of passenger and cargo transport ships. With lower water levels and depth preventing navigation, this transport service ceased after 1903. This suggest considerable alteration of the hydrology, geomorphology and physico-chemical characteristic in the Elephant Marsh, but there is little data to confirm how the biotic communities changed. *In situ* water quality parameters measured indicate low dissolved oxygen levels and apparent high water temperatures (Table 18), although there is no comparable water temperature data from pristine conditions. Water temperature affects and is affected by total suspended solids, dissolved oxygen concentrations, and several other water quality parameters, which could also have changed over time.

At the sites (NEM and SEM) sampled in the different regions of the Elephant Marsh, community composition of the aquatic macroinvertebrates changed from the NEM to the SEM region (Appendix 2C, Figures C9 – C12). These changes are linked to hydrological, geomorphological and physico-chemical alterations. The bottom substrate was unfortunately not sampled (see paragraph 2 in section 3.4.2). Information on this substrate could clarify the direct impacts of high sand movement and deposition within the system on burrowing and benthic taxa. As expected, the composition of taxa recorded in the marginal vegetation biotope was strongly driven by flow-type.

Most of the aquatic macroinvertebrates naturally respond relatively quickly to changes in hydrology and the subsequent direct and indirect influence on the systems geomorphology and physico-chemical properties. The success of, for example, Odonata species (nymph-emergence-adult) in a system is linked to hydrological type (flow velocity and hydroperiod), the vegetative structure, and predation-competition (Crumrine *et al.* 2010; McPeek 2010). A number of Odonata species are adapted to the seasonality of lowland rivers, with obligate migration common and widespread amongst many African species (Suhling *et al.* 2006). In Austria, Chovanec & Waringer (2001) used Mollusca, Trichoptera, Odonata, Amphibia and fish as umbrella groups over different periods to determine lateral connectivity and understand conditions and long term responses to changes.

#### *3.7.2.3 Western clear water lake*

The western clear water lake is a permanent inundation dependant on its landscape topography and connection to the Shire River. Water inflow and the lack of inflow is the main driver dictating environmental conditions in this part of the system. Exchanges of nutrients and energy between the floodplain and river channel is facilitated by natural flood cycles. Currently large expanses of aquatic vegetation (Figure 19), mainly hornwort (*Ceratophyllum demersum*) and lotus water lilies (*Nymphaea lotus*), dominate presumably shallow (depth not physically measured) open areas. This is symptomatic of permanent water and extended periods of low flow. *C. demersum* is generally associated with stagnant or slow flowing eutrophic to brackish waters, while *N. lotus* is associated with both temporary and permanent water up to depths of 2.5 m (Cook 2004).

**Figure 19. The dominant aquatic vegetation in the "open" presumably shallower parts of the western clear water Lake is hornwort *Ceratophyllum demersum* with patches of lotus water lilies *Nymphaea lotus* (Photo G Diedericks).**

The high concentration of dissolved oxygen measured (Table 18) is mainly as a result of this high density of aquatic plants. The dissolved oxygen will fluctuate in the water column, affected by the build-up of decaying organic matter in the lower levels, and lack of flow-flushing on the system. Dissolved oxygen concentrations will also vary between day and night, eliminating taxa sensitive to such change in environmental conditions.

## 3.8 Present status based on invertebrate indicators

It is difficult to determine the reference conditions since historical data is lacking. Timberlake (1998) suggests that the existence of the floodplains and wetlands of the Lower Shire River are evolutionary young, since low water levels in Lake Malawi (source of Shire River) for extended periods would have affected their size and extent. Shela (2000) stated that human and cargo transport carriers up the Shire River from Mozambique was stopped in 1903 because of water depth limitations, and never resumed. Some of the factors affecting the invertebrate community are shown in Figure 20.

Nevertheless, the SASS methodology is designed to estimate present condition based on the taxa found at a site. The *estimated* reference conditions for the west flowing rivers (RV sites) are presented separately from the NEM, SEM and WEM areas. This is since wadeable river conditions based on taxa recorded and expected is easier to quantify, whereas the conditions in the Shire River floodplain is with less confidence.

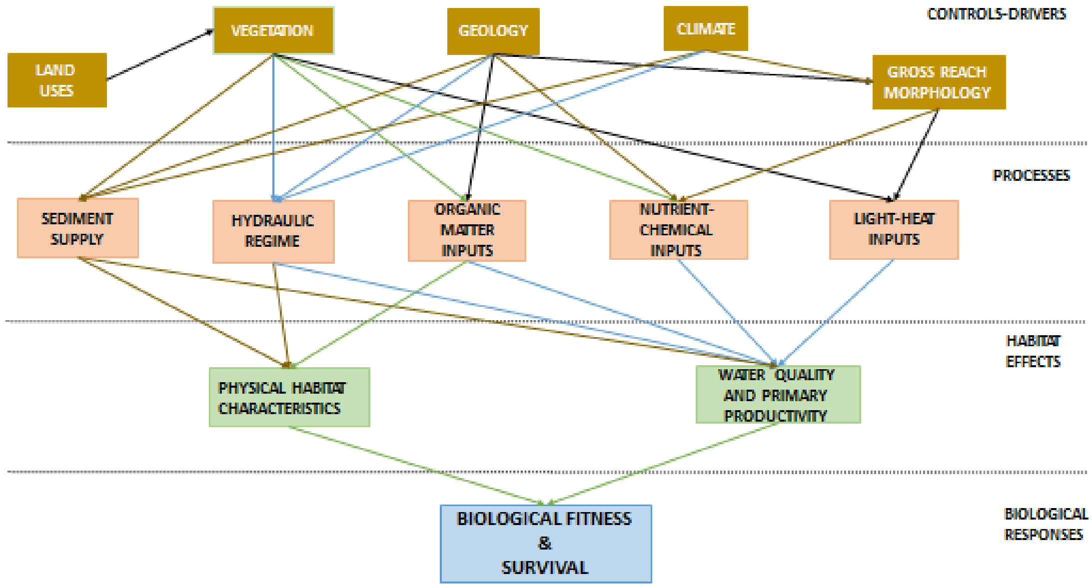


**Figure 20. The relationships between the drivers and processes, the effect of these processes on habitat and the related responses illustrated in a schematic diagram (Beechie & Bolton 1999, cited in Kleynhans & Louw 2008, pg. A2-6).**

### 3.8.1 Westward-flowing tributaries

The instream habitat is severely altered as a consequence of high sediment input and deposition. The high suspended solids in the water will generally increase water temperature as additional heat is absorbed. The instream habitat and water temperature changes interact with dissolved oxygen, salinity, conductivity, total dissolved solids, water density, metabolic rates and photosynthesis, carbon dioxide, and water pH. These interactions compound toxicity changes (Dallas & Day 2004, Dodds & Whiles 2010). Water temperatures in the west-flowing tributaries ranged from 27.8 – 30.9°C, slightly higher than in the Shire River (Table 18). The usually diverse stones biotope is embedded with sand, and a sand-blasting effect further reduces taxa diversity during high flow events. The marginal vegetation biotope is limited as a result of stream bank scouring and riparian vegetation removal.

These man-made changes have heavily impacted on the aquatic biota to the exclusion of certain taxa. Several taxa could be expected but very few were recorded during this once-off survey. Key taxa not encountered in the river sites (RV) but expected include:

- Plecoptera: Perlidae;
- Ephemeroptera: Heptageniidae, Leptophlebiidae, Oligoneuridae, and Polymitarcidae;

- Odonata: Calopterygidae, Chlorocyphidae, and Macromiidae;
- Hemiptera: Belistomatidae and Gerridae;
- Trichoptera: Ecnomidae, Philopotamidae, and Leptoceridae;
- Coleoptera: Elmidae, Scirtidae and Psephenidae, and;
- Diptera: Athericidae, Dixidae, Simuliidae and Tipulidae.

These families are mostly associated with a high preference for cobble-riffle-run and marginal vegetation biotopes.

The assessment of current conditions in comparison with expected reference conditions is illustrated in Figure 21. The condition of the west flowing tributaries are considered as severely modified (E), having little resemblance to their original state (A). The major problem is the lack of natural vegetation, riparian zones, and erosion control, causing high sediment input, movement and deposition. Although historical data on rivers in the Lower Shire region is scarce, families expected and considered key indicators of improved conditions in terms of cobble-boulder/riffle-run and marginal vegetation biotopes are included in Table 21. Taxa listed in Table 21 recorded at the river sites (even if only one) are in bold font.

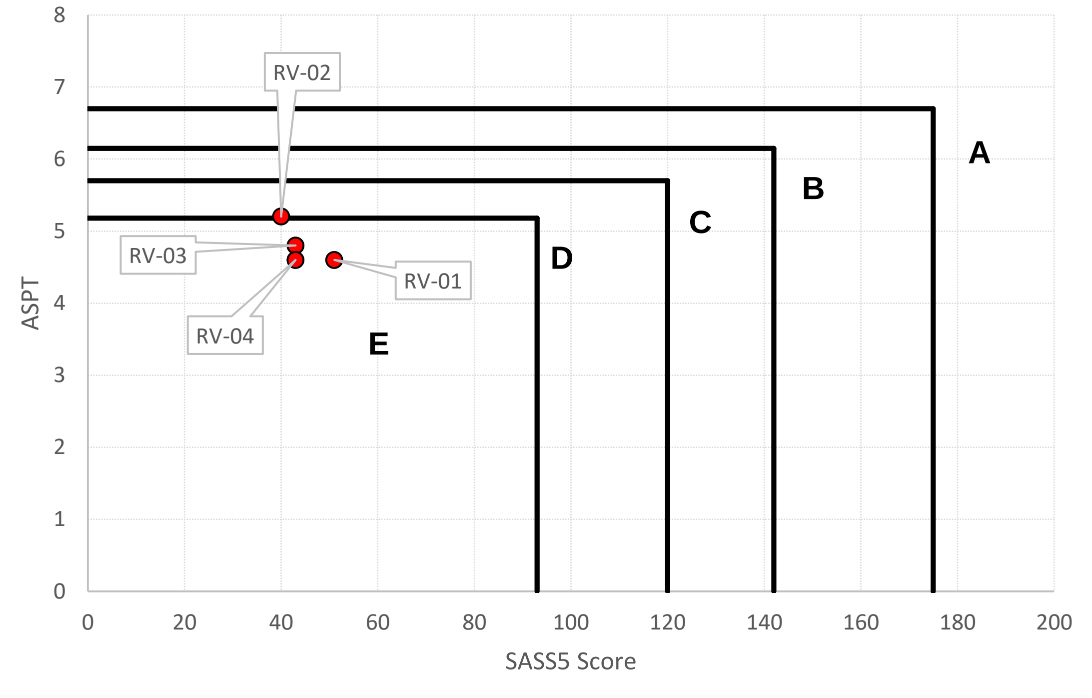


**Figure 21. Biological bands for the Lowveld Aquatic Ecoregion based on percentiles calculated for sites located in the lower foothills and lowland rivers within southern African.**

**Table 21. A list of key taxa expected and which would indicate improved conditions in the stones and marginal vegetation biotopes. Taxa in bold font indicate presence at the four river sites (RV).**

| Taxa | Cobble-boulder / riffle-rapid-run | Marginal vegetation |
|---|---|---|
| Plecoptera | Perlidae | |
| Ephemeroptera | Heptageniidae (run-glide) | Heptageniidae (in current) |
| | **Tricorythidae** | Leptophlebiidae (out of current) |
| Odonata | Libellulidae (***Zygonyx*** & *Zygonoides* spp.) | Chlorocyphidae |
| | | **Coenagrionidae** (in & out of current) |
| Trichoptera | **Hydropsychidae** | Leptoceridae |
| | Philopotamidae | |
| Coleoptera | Elmidae | Scirtidae |
| | Psephenidae | |
| Diptera | Simuliidae | Simuliidae (in current) |
| | | Dixidae (out of current) |

### 3.8.2 Marshes

Based on the limited abundance of flow- and habitat-sensitive taxa within the Elephant Marsh, and the high diversity and abundance of flow- and pollution-tolerant taxa, the present ecological state of this system more than likely falls within a moderately impaired class (lower C). This is because habitat heterogeneity is still high, even though the system is severely affected by flow (lack of flow and increased peak flows), water turbidity and sediment inputs and deposition. The marshes are still functional as a flood-plain wetland, but, over time, there has probably been an overall increase in temporal biota (especially highly resilient species) and decrease in flow and permanent species.

### 3.8.3 Overall condition

Overall, the condition of the Elephant Marsh was judged to be in a D state.

# 4 DRAGONFLIES AND DAMSELFLIES

## 4.1 Introduction

Odonata (dragonflies and damselflies) are the most conspicuous freshwater insects, being one of the few well-known groups that represent both this vital resource, water, and the largest class of animal diversity, insects. Due to their attractive appearance, they are receiving increasing attention from the public, conservationists and scientists on regional and global levels (Clausnitzer *et al.* 2009, Kalkman *et al.* 2008). Human disturbance of watersheds, with the consequent loss of soil and water-sources, is a problem world-wide, especially in the tropics, and certainly in Africa. For the above reasons, Odonata were selected as one of the animal groups for which the diversity and status in the Elephant Marsh should be assessed.

Malawi's Odonata are comparatively well-known and species-rich. Dijkstra & Clausnitzer (2014) listed 152 species (plus one in error, see below), which is 90% of the total number predicted to occur by Dijkstra & Clausnitzer (2006). By comparison, 135 species (86% of the predicted list) are recorded from Mozambique. Two species are endemic and both are listed as Critically Endangered on the IUCN Red List of Threatened Species: the Mulanje Damsel *Oreocnemis phoenix* from Mt Mulanje and Ntchisi Yellowwing *Allocnemis maccleeryi* from Mt Ntchisi. The Blue-lipped Yellowwing *A. montana* is Endangered and occurs only in the Misuku Hills of the extreme north, from where it extends into adjacent Tanzania. Three Vulnerable species (Elegant Malachite *Chlorolestes elegans*, Green-banded Sparklewing *Umma declivium*, Eastern Horntail *Nepogomphoides stuhlmanni*) are more widespread, but also restricted to Afromontane sites. The Malawi Hooktail *Paragomphus nyasicus* is largely endemic to Lake Malawi, while the form 'lacus' of the Dancing Jewel *Platycypha caligata* there may also represent a valid species, but neither taxon is considered under threat.

The Odonata Database of Africa (ODA; Clausnitzer *et al.* 2012) contains only five records (all by John Wilson) of four species from Malawi south of Chikwawa: *Pseudagrion coeleste*, *Aethriamanta rezia*, *Orthetrum chrysostigma* and *Urothemis edwardsii*. Dijkstra & Clausnitzer (2014) erroneously listed *Pseudagrion helenae* for Malawi, but two males collected at "Sucoma and Alumenda", which must refer to the sugar plantation near Alimenda (entrance to Lengwe National Park, have been re-identified as *P. coeleste*. Although the Odonata of Malawi's extreme south are thus essentially unstudied, Parr (1984) undertook an extensive survey of Liwonde National Park along the Shire River upstream from the Elephant Marsh. He recorded 61 species of which 36 were associated with the main river, all of them widespread in Africa.

On the basis of Parr's findings and the fact that all sensitive Malawian species are confined to forested and/or mountain streams, it seems likely that the Elephant Marsh lack localised Odonata. However, the large swamps further east (e.g. in Zambia and Botswana) harbour numerous ecologically sensitive and range-restricted species. As some of these occur isolated on the northern KwaZulu-Natal coast and Mozambique has been poorly studied, a survey of the marshes on the lower Shire was considered worthwhile.

## 4.2 Survey methods

Because adult are conspicuous, a fair picture of local diversity can be obtained within a few days or weeks, depending on an area's size. Adults are active throughout the year, although the late wet season may be best for recording (Parr 1984). Sampling in and around the Elephant Marsh took place for five days from 8 to 12 March 2016. An effort was made to inspect as much of the marshes as possible by boat in order to identify microhabitats that may harbour unusual species (Figure 22, Figure 23). Adults were observed and caught with a hand net during daylight. Identifications were made using Dijkstra & Clausnitzer (2014). Due to habitat and behaviour, only observation frequency can provide some measure of relative abundance. Therefore time was invested in trying to find as many species as possible, rather than quantify their numbers. Habitats were found to be very homogeneous and therefore results are only listed for the Nchalo area (mostly Nyala Park) and the Elephant Marsh proper (mostly the lagoons near Kaombe, a similar suite of species were found from the Nchalo side). Additional records were obtained from Gerhard Diedericks (aquatic invertebrate specialist), who visited the area from 17 to 21 January 2016.

The March Odonata survey lasted only one week in a very hot period of an exceptionally dry wet season. Although the period was chosen to coincide with the optimal time indicated by Parr (1984), he found some adults to be seasonal and therefore some species are likely to have been missed. Moreover, access to aquatic habitats was difficult and potentially special sites were impossible to reach. However, given that the Shire floodplains are a very dynamic system, with extreme water-level fluctuations, constantly shifting vegetation, and turbid and eutrophic water, the overall impression was that stable and unusual habitats (e.g. nutrient-poor bogs or clear shallow streams) do not exist in the system.


**Figure 22. The boat used for survey on the water. L-R Kwondwani, N. Avenant and KD Dijksra (Photo: D. Allen).**

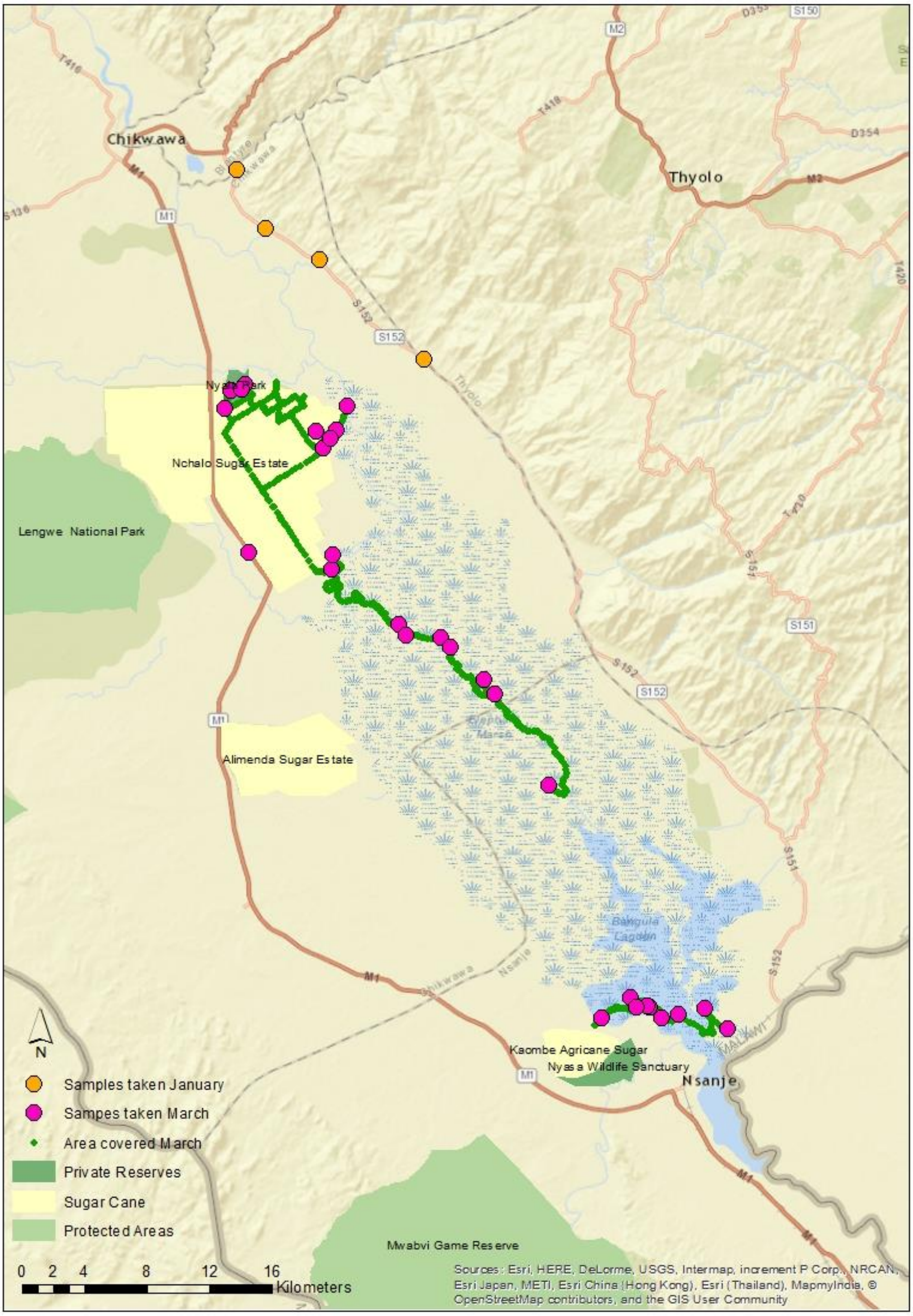


**Figure 23. Sampling locations during the March dragonflies and damselflies survey. Sampling points where additional specimens were collected during Januray aquatic invertebrate survey are also included.**

## 4.3 Survey results

Only 36 species were recorded during the project, of which 27 during the March survey, 24% of the species now known from Malawi (Table 22). None are of conservation concern. All four species recorded previously in the region were found again.

Only 20 of these 36 species were observed in the Elephant Marsh proper. During both surveys, just six species made up the bulk of the high densities of individuals, particularly on the floating vegetation: *Ischnura senegalensis*, *Brachythemis leucosticta*, *Crocothemis erythraea*, *Diplacodes lefebvrii*, *Orthetrum trinacria* and *Urothemis edwardsii*. More sporadic were *Ceriagrion glabrum*, *Ceriagrion kordofanicum*, *Pseudagrion coeleste*, *Pseudagrion massaicum*, *Anax imperator*, *Ictinogomphus ferox*, *Acisoma variegatum*, *Aethriamanta rezia*, *Pantala flavescens*, *Rhyothemis semihyalina*, *Tramea basilaris*, *Trithemis annulata* and *Urothemis assignata*. Interestingly, during the January survey G. Diedericks found very high numbers of *A. rezia* adults and larvae in the emergent and floating vegetation, as well as several adults of *P. coeleste* of which two and no adults respectively were seen in March. This indicates the extreme seasonality of the system. The only truly riverine species found along the Shire was *Pseudagrion acaciae*.

Fourteen additional species were found around the Nchalo plantation, especially in Nyala Park. Most of these also favour temporary water bodies, but often smaller and more sheltered: *Aciagrion gracile*, *Pseudagrion hamoni*, *Pseudagrion lindicum*, *Anax tristis*, *Diplacodes luminans*, *Hemistigma albipunctum*, *Nesciothemis farinosa*, *Orthetrum brachiale*, *Orthetrum stemmale* and *Tholymis tillarga*. G. Diedericks found a few adults of *Elattoneura glauca* and *Orthetrum chrysostigma* at the channel in Nyala Park, as well as larvae of *Gomphidia* and *Olpogastra*, which based on distribution can only be *G. quarrrei* and *O. lugubris*. These are all widespread species of open flowing waters.

Diedericks also sampled four of the Shire's west-flowing tributaries in January and found two additional species. He found only four adult *Pseudagrion kersteni* and a larva of *Zygonyx torridus* at one river and lots of larvae of *Paragomphus* or *Crenigomphus* at all sites, but the latter cannot be identified to species. This poor result is consistent with these rivers' severe sedimentation due to poor land management.

**Table 22. Odonata species recorded in the Shire valley. Legend: S — found in Southern Malawi (1: by K.-D.B. Dijkstra; 2: by G. Diedericks); E — in Elephant Marsh (1: single adult seen; S: several adults; M: many adults); N — in Nchalo area, especially Nyala Park (1; S; M: as above); L — listed for Liwonde National Park by Parr (1984; number indicates number of months of the year observed).**

| Scientific name | Vernacular name | S | E | N | L |
|---|---|---|---|---|---|
| **ZYGOPTERA Selys, 1854** | | | | | |
| **Lestidae Calvert, 1901** | | | | | |
| *Lestes uncifer* Karsch, 1899 | Sickle Spreadwing | | | | 3 |
| *Lestes ictericus* Gerstäcker, 1869 | Tawny Spreadwing | | | | 4 |
| **Calopterygidae Selys, 1850** | | | | | |
| *Phaon iridipennis* (Burmeister, 1839) | Glistening Demoiselle | | | | 6 |
| **Chlorocyphidae Cowley, 1937** | | | | | |
| *Platycypha caligata* (Selys, 1853) | Dancing Jewel | | | | 2 |
| **Platycnemididae Yakobson & Bianchi, 1905** | | | | | |
| *Elattoneura glauca* (Selys, 1860) | Common Threadtail | 2 | | S | 3 |

| Scientific name | Vernacular name | S | E | N | L |
|---|---|---|---|---|---|
| **Coenagrionidae Kirby, 1890** | | | | | |
| *Aciagrion gracile* (Sjöstedt, 1909) | Graceful Slim | 1 | | S | |
| *Africallagma fractum* (Ris, 1921) | Slender Bluet | | | | 1 |
| *Africallagma subtile* (Ris, 1921) | Fragile Bluet | | | | 1 |
| *Agriocnemis exilis* Selys, 1872 | Little Wisp | | | | 6 |
| *Agriocnemis gratiosa* Gerstäcker, 1891 | Gracious Wisp | | | | 8 |
| *Ceriagrion glabrum* (Burmeister, 1839) | Common Citril | 1 | S | S | 12 |
| *Ceriagrion kordofanicum* Ris, 1924 | Little Orange Citril | 1 | S | | 7 |
| *Ischnura senegalensis* (Rambur, 1842) | Tropical Bluetail | 1 | M | S | 12 |
| *Pseudagrion acaciae* Förster, 1906 | Acacia Sprite | 1 | S | S | 6 |
| *Pseudagrion coeleste* Longfield, 1947 | Catshead Sprite | 2 | S | S | 8 |
| *Pseudagrion hamoni* Fraser, 1955 | Swarthy Sprite | 1 | | M | 8 |
| *Pseudagrion kersteni* (Gerstäcker, 1869) | Powder-faced Sprite | 2 | | | 7 |
| *Pseudagrion lindicum* Grünberg, 1902 | Eastern Blue Sprite | 1 | | S | |
| *Pseudagrion massaicum* Sjöstedt, 1909 | Masai Sprite | 1 | S | M | 9 |
| *Pseudagrion sublacteum* (Karsch, 1893) | Cherry-eye Sprite | | | | 2 |
| *Pseudagrion sudanicum* Le Roi, 1915 | Blue-sided Sprite | | | | 7 |
| **ANISOPTERA Selys, 1854** | | | | | |
| **Aeshnidae Leach, 1815** | | | | | |
| *Anaciaeschna triangulifera* McLachlan, 1896 | Evening Hawker | | | | 1 |
| *Anax ephippiger* (Burmeister, 1839) | Vagrant Emperor | | | | 2 |
| *Anax imperator* Leach, 1815 | Blue Emperor | 1 | 1 | | 7 |
| *Anax tristis* Hagen, 1867 | Black Emperor | 2 | | 1 | 2 |
| *Gynacantha manderica* Grünberg, 1902 | Little Duskhawker | | | | 4 |
| **Gomphidae Rambur, 1842** | | | | | |
| *Gomphidia quarrei* (Schouteden, 1934) | Southern Fingertail | 2 | | S | |
| *Ictinogomphus ferox* (Rambur, 1842) | Common Tigertail | 1 | 1 | 1 | 10 |
| *Paragomphus elpidius* (Ris, 1921) | Corkscrew Hooktail | | | | 1 |
| **Macromiidae Needham, 1903** | | | | | |
| *Phyllomacromia picta* (Hagen in Selys, 1871) | Darting Cruiser | | | | 2 |
| **Libellulidae Leach, 1815** | | | | | |
| *Acisoma variegatum* Kirby, 1898 | Slender Pintail | 1 | S | S | 9 |
| *Aethriamanta rezia* Kirby, 1889 | Pygmy Basker | 1 | M | | 1 |
| *Brachythemis lacustris* (Kirby, 1889) | Red Groundling | | | | 5 |
| *Brachythemis leucosticta* (Burmeister, 1839) | Southern Banded Groundling | 1 | M | S | 12 |
| *Chalcostephia flavifrons* Kirby, 1889 | Inspector | | | | 10 |
| *Crocothemis divisa* Baumann, 1898 | Rock Scarlet | | | | 3 |
| *Crocothemis erythraea* (Brullé, 1832) | Broad Scarlet | 1 | M | M | 12 |
| *Diplacodes lefebvrii* (Rambur, 1842) | Black Percher | 1 | M | S | 10 |
| *Diplacodes luminans* (Karsch, 1893) | Barbet Percher | 1 | | M | 5 |
| *Hemistigma albipunctum* (Rambur, 1842) | African Piedspot | 1 | | 1 | 12 |
| *Nesciothemis farinosa* (Förster, 1898) | Eastern Blacktail | 1 | | S | 1 |
| *Olpogastra lugubris* Karsch, 1895 | Bottletail | 2 | | S | 5 |
| *Orthetrum abbotti* Calvert, 1892 | Little Skimmer | | | | 1 |

| Scientific name | Vernacular name | S | E | N | L |
|---|---|---|---|---|---|
| *Orthetrum brachiale* (Palisot de Beauvois, 1817) | Banded Skimmer | 1 | | 1 | 6 |
| *Orthetrum caffrum* (Burmeister, 1839) | Two-striped Skimmer | | | | 1 |
| *Orthetrum chrysostigma* (Burmeister, 1839) | Epaulet Skimmer | 2 | | 1 | 6 |
| *Orthetrum stemmale* (Burmeister, 1839) | Bold Skimmer | 1 | | S | 2 |
| *Orthetrum trinacria* (Selys, 1841) | Long Skimmer | 1 | M | 1 | 7 |
| *Palpopleura deceptor* (Calvert, 1899) | Deceptive Widow | | | | 2 |
| *Palpopleura lucia* (Drury, 1773) | Lucia Widow | | | | 8 |
| *Pantala flavescens* (Fabricius, 1798) | Wandering Glider | 1 | S | S | 8 |
| *Rhyothemis semihyalina* (Desjardins, 1832) | Phantom Flutterer | 1 | S | | 9 |
| *Tetrathemis polleni* (Selys, 1869) | Black-splashed Elf | | | | 1 |
| *Tholymis tillarga* (Fabricius, 1798) | Twister | 1 | | 1 | 3 |
| *Tramea basilaris* (Palisot de Beauvois, 1817) | Keyhole Glider | 2 | S | | 2 |
| *Trithemis annulata* (Palisot de Beauvois, 1807) | Violet Dropwing | 1 | S | S | 12 |
| *Trithemis arteriosa* (Burmeister, 1839) | Red-veined Dropwing | | | | 12 |
| *Trithemis kirbyi* Selys, 1891 | Orange-winged Dropwing | | | | 1 |
| *Trithemis werneri* Ris, 1912 | Elegant Dropwing | | | | 1 |
| *Trithetrum navasi* (Lacroix, 1921) | Fiery Darter | | | | 1 |
| *Urothemis assignata* (Selys, 1872) | Red Basker | 1 | 1 | S | 9 |
| *Urothemis edwardsii* (Selys, 1849) | Blue Basker | 1 | M | | 12 |
| *Zygonoides fuelleborni* (Grünberg, 1902) | Southern Riverking | | | | 2 |
| *Zygonyx torridus* (Kirby, 1889) | Ringed Cascader | 2 | | | 1 |

## 4.4 Description of present-day biota

Of the 36 species recorded, only about 15 were seen more frequently, and only six or seven made up the bulk of the abundant individuals encountered in the marshes. The fauna is thus species poor and dominated by a handful of species that respond well to the very dynamic environment.

Because Parr (1984) recorded in all months of the year, Liwonde provides a good comparison for our survey. The most frequent species there agree strongly with those predominating downstream. Only five frequent species at Liwonde (observed for more than half of the year), were absent from our surveys. However, *Chalcostephia flavifrons*, *Palpopleura lucia* and *Trithemis arteriosa* are among Africa's most abundant species of standing waters, while *Agriocnemis gratiosa* and *Pseudagrion sudanicum* can be common in extensive and often temporary marshes. Their apparent absence (or at least rarity and/or extreme seasonality, see comments on *P. coeleste*) further confirms the impression that the Elephant Marsh only supports specialists of a more dynamic environment than even such ubiquitous species can't tolerate.

The most notable species shared by both areas is *Ceriagrion kordofanicum*, which is widespread across eastern Africa but only over floating vegetation, particularly of water lettuce *Pistia stratiotes*. The latter is known as a highly invasive weed in Africa, but has probably been present for millions of years (Renner & Zhang 2004). Most likely *C. kordofanicum* evolved with this plant and now benefits from impacts that favour its mass development, such as eutrophication.

Among the scarcer species at Liwonde are many of larger and smaller species that inhabit running water habitats (*Phaon iridipennis*, *Platycypha caligata*, *Pseudagrion sublacteum*, *Paragomphus elpidius*, *Brachythemis lacustris*, *Trithemis kirbyi*, *Trithemis werneri* and *Zygonoides fuelleborni*). Some of these species might occur on the Shire's tributaries where running water is more permanent, but seem to be absent from the main channel within the Elephant Marsh.

The only two species found in our survey but not at Liwonde are *Aciagrion gracile* and *Pseudagrion lindicum*. Both are inconspicuous slender blue damselflies found in Nyala Park at a shaded temporary pool with much emergent vegetation. They were only seen in the late afternoon and thus appear to be crepuscular and easily overlooked. *P. lindicum* was not previously recorded from Malawi, although ODA contains an unconfirmed record on 13 April 1976 from Salima near Lake Malawi by Mike Parr. The new record thus represents the only significant finding of the survey. The record falls well within the species' range from Mozambique across Tanzania and Kenya to Somalia, where most records are from drier and lower-lying (often coastal) sites.

## 4.5 Present status of Odonata

Based on the above, the Odonata fauna is considered largely natural (81-90% similar to natural), although the *Pistia* specialist *C. kordofanicum* may have profited from the expansion of that weed (Figure 24). Other specialists, like those of large rivers may be absent because good quality river habitat on the Shire has become rarer due to siltation and turbidity. *P. acaciae* was the only such specialist observed, but river species are also easily missed during a five-day survey.

**Figure 24. *Ceriagrion kordofanicum* (left) is strictly associated with water lettuce *Pistia stratiotes* (right) and probably benefits from impacts that favour this highly invasive weed's mass development**

# 5 BUTTERFLIES

## 5.1 Introduction

The aim of this butterfly survey was to establish an inventory of species occurring on and around the Elephant Marsh, to ascertain whether there are species/populations of conservation importance, and to get an indication of the current health of the system.

The Butterflies of Malawi was written in 1965 by David Gifford and printed locally by the Heatherwick Press in Blantyre. It is not a user-friendly document, giving many references and only very few (9) poor plates. From this we assembled a list of 607 species of butterfly which occur in Malawi (there are around 4 000 species in Africa and 700 species in the whole of the Republic of South Africa). This suggests that Malawi is fairly species rich for such a small country. However, exponential population growth has created enormous pressure on a fragile environment and many of the original habitats either no longer exist or have been highly modified.

Of the estimated 607 butterfly species in Malawi, some 10% are endemic (Murphy 2015 pers. comm). A short butterfly survey has previously been carried out in the study area by Dowsett-Lemaire & Dowsett (2002) as part of their work on the butterflies of Majete, Lengwe and Mwabvi Reserves, yielding some 101 species (Appendix 3D). The only other area that could be considered similar to the Elephant Marsh would be the Okavango Delta in Botswana, which consists of Islands where the methods of transport is by canoe (mokoro), aircraft or airboat similar to that which is required in the current study area. However, no comprehensive butterfly surveys have been carried out in this location either.

In the study area, the eastern shoreline, north-western and south-western banks are densely populated. While the western bank is also heavily populated, large areas of sugar plantations are found adjacent to the marsh. While the west side contain large tracts of cultivated land, they also retain some natural vegetation although this was also a mostly regrowth from previously cultivated areas e.g. Nyala (Illovo), Nyasa (Kaombe).

## 5.2 Survey methods

The Elephant Marsh butterfly survey was carried out on 25 - 29 June 2015. The marsh edge was sampled at two sites on the West Bank (North, South) and two sites on the East Bank (North, South; Figure 26).

Methods of sampling included the use of hand nets (Figure 25) and traps baited with fermented banana at Nyasa Reserve on the Kaombe Sugarcane estate in the South and the Nyala Park on the Nchalo sugarcane estate in the North (although the baited traps created problems with monkeys eating the bait). Foodplants were also examined for caterpillar feeding and recording of early stages. Assistance was provided by Dr Julian Bayliss during the fieldwork period.

The original plan was to do four transects across the marsh at differing latitudes down the marsh. Unfortunately this was not possible due to difficulties of access. The use of a four-wheel drive vehicle enabled us to survey the whole periphery of the marsh (approximately 180 km) apart from the bottom few kilometres from Bangula/Chiromo to the new course of the River Ruo on the south-east side, which had become impassable in the previous floods.

**Figure 25. Collecting in Polygononum in Marsh. Home of Neptis jordani . L-R J. Bayliss, S. Collins, R. Nyrienda.**

At the lower end of the marsh there was enormous human population pressure. Phragmites reeds and papyrus were being burnt in the swamp to clear land for agriculture (see photos). The principle crops were maize (with two crops being able to be grown each year due to the climate), rice, some vegetables/legumes (beans) as well as high grazing pressure levels from cattle and goats.

The fairly frequent graveyards along the roadside villages were also examined. The locals plant trees and leave the vegetation undisturbed these act as 'islands' of increased biodiversity. Other islands were the regenerated "parks" of (Nyala Park) belonging to Illovo Sugar (Sucoma) and at Kaombe AgriCane Sugar Company (Nyasa Reserve). These areas seem generally respected. The nectaring plants that were common in the wetland areas and on the mainland were *Spheranthus suaveolus* and various *Cruciferae Cadaba* and *Merua sp*.

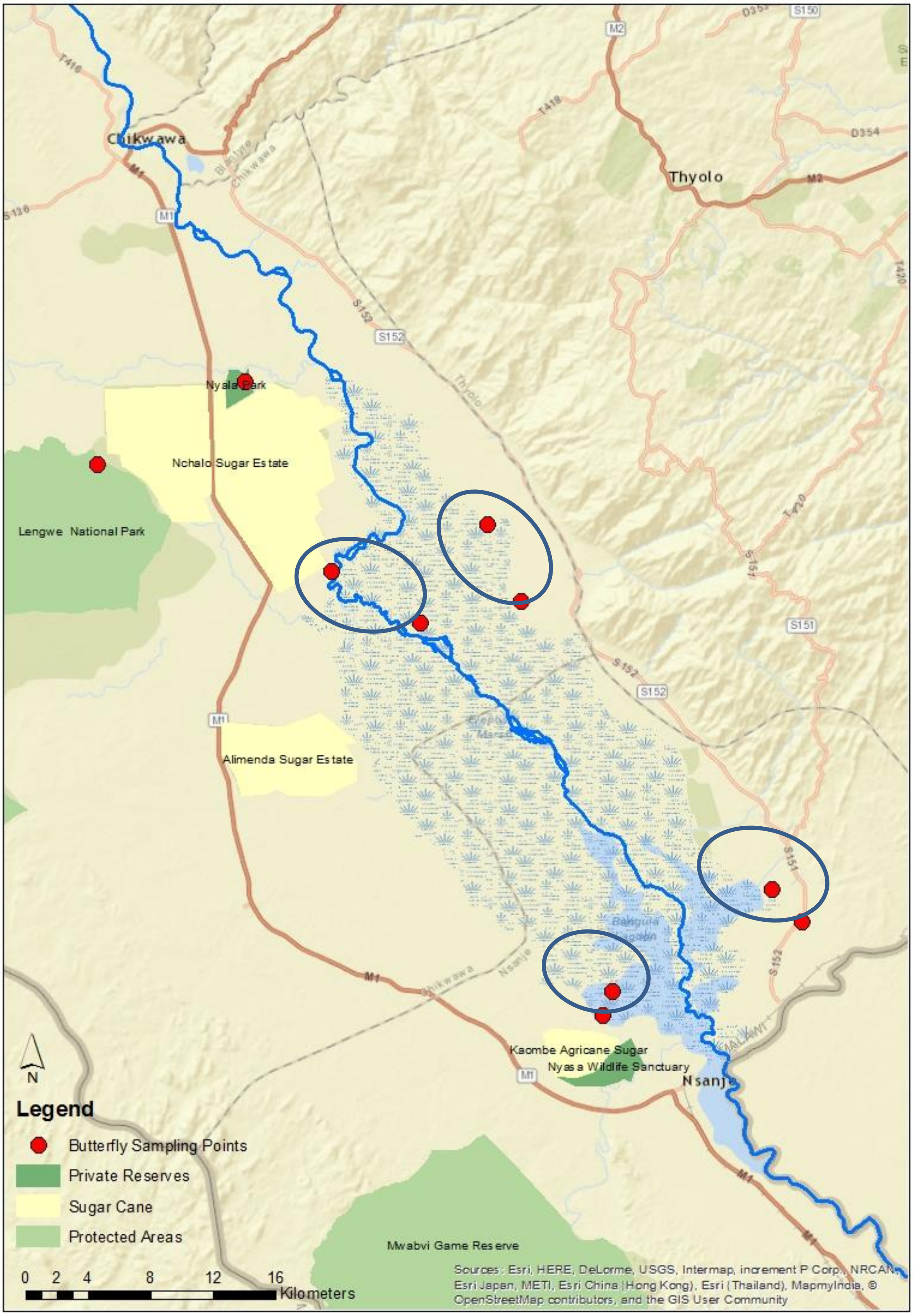


**Figure 26. Sampling sites for butterflies.**

## 5.3 Survey results

### 5.3.1 Site 1 - Kaombe Pumphouse and Sugar Estates (west side south)

This was the only site where we could access the Marsh on the water and where 53 species were sampled of a total 62 species from all sites (Figure 26, Appendix 3A and 3B). Four species of butterflies were recorded from plants on the water, and one *Neptis jordani* was only found there. The latter feeds on *Polygonum* species, found in aquatic conditions from the north-eastern coast of South Africa to Kenya. Two species (*Polygonum* feeding) that might have also been expected to occur were *Mylothris rubricostata* (found in Liwonde Swamp) and *Acraea rahira*. However 64m a.m.s.l. is a rather low altitude for these species to occur, and both species are present in Malawi at higher altitude. Site 1 was the least damaged site although there is enormous pressure from fishermen living on the lake shore and any form of tree or wood is rare. This will also impact on their fishing lifestyle as there are no trees nearby for hollowed out canoes and most were heavily patched and not very 'marsh worthy'. So even where big agribusiness occurs the subsistence fishermen degrade the marsh itself.

### 5.3.2 Site 2 – North-east side of Marsh

This site was opposite the big Illovo Nchalo Sugar Plantations (Figure 26, Appendix 3A and 3B). Here 33 species were found considerably poorer and more degraded vegetation. The village graveyards which have spiritual significance were butterfly refuges as the vegetation has largely been allowed to develop naturally and the sites are respected by the local people. The common pioneer species *Acraea serena* associated with this altitude and vegetation type was mostly present and the *Merua/Cadaba* feeders were present on termite mounds which sustained their host plants.

### 5.3.3 Site 3 - Nchalo/Nyala Park (north west side)

This site was on the edge of the marsh where the Illovo Nchalo Estate (Figure 26) is present. Again vegetation regrowth had allowed other species to appear, but many of those which live on the older dicotyledonous host plants were absent. Several pioneer species were dominant. Thirty-six species were recorded in this site.

### 5.3.4 Site 4 – South-east of the Marsh near the Ruo River entry point.

This site (Figure 26, Appendix 3A and 3B). gave the sparsest results: only 20 species. This part of the marsh had been extensively flooded and the marsh had receded extensively over the previous months much of the original vegetation had been submerged and drowned and only a few annual crops were battling for survival. The butterflies were mostly the pioneer species: *Acraea serena, Acraea encedon, Zizeeria knysna, Catopsilia florella.*

## 5.4 Description of present-day biota

There were a total of a hundred species recorded by the Dowsetts in 2002 from the 3 major surrounding conservation areas: Lengwe, Majete and Mwabvi. They also collected at the beginning of the rains so many species which only emerge once a year would have been there had sampling taken place in January rather than June). Whereas there were 101 species sampled by Dowsetts from the 3 conservation areas sampled across different times of the year, this survey found 61 species of which 22 had not been recorded by the Dowsetts. Species lists for each of the four sites as well as those recorded by the Dowsett-Lemaire & Dowsett (2002) in the three nearby conservation areas are provided in Appendix 3B.

Of the butterfly species recorded by Dowsett-Lemaire & Dowsett (2002), it would be expected that virtually all these species would have been found if intensive sampling could have been conducted in both rainy and dry seasons. At least 37 of the listed species would definitely occur based on the presence of the following food plants:

- Lecaniodiscus not in good leaf – Food plant Euxanthe, various *Charaxes Neptis*
- Lycaenids needing aphids/scales/seeds of some plants
- Flat Hesperiidae (Skippers)- on grasses, and plants like Grewia

This study was based on only a brief survey, although a new race of butterfly was recorded within the short survey period of a few days. In total, if sampled more thoroughly over multiple times of the year, we would expect to find 150 species of butterfly in the survey area, 100 Dowsett + 22 species unrecorded by the Dowsetts = 122, plus additional species which are expected to be present based on food plant suitability. This is about 25% of Malawi's butterfly fauna. However, in the heavily populated areas on the eastern side of the swamp, species numbers would be unlikely to be more than 40, which is only 6% of Malawi butterfly species.

The only uniquely special species was the *Colotis amata* (see Figure 28). This was breeding exclusively on *Salvadoria persica* (toothbush/salt bush) on the lake edge. This plant will not be threatened by habitation as it offers shade for small ruminants, some food and is used by the population. Most of the trees have been cut, a few lone *Hyphaene* palms exist on islands in the marsh.

Certain pioneer species such as Acraea *serena*, *Acraea encedon*, *Danaus chrysippus*, *Zizeeria knysna*, *Catopsilia florella* will flourish even under the most degraded conditions. So these pioneers may be 50% of the species found in the South-East Marsh sample.

There was extensive burning on the eastern side of the marsh taking place in order to clear reeds and provide news areas for cultivation. Large mammals (other than cattle) were virtually non-existent. The pioneer grasses *Cynodon/Vossia* rushes *Ipomea* in particular and *Commelina* were recolonizing the receding flooded area where standing rushes had been drowned in the flood.

Both *Ipomea* and *Commelina* are pioneer species of plant. These are the food plants for *Acraea serena* and *Acraea encedon* (see Figure 27) both these species occur all over Subsaharan Africa and in Madagascar and these species of butterly will be found where these host plants occur.

There was one new species of butterfly for Malawi and one species (or race) new to science. This species breeds on salt bush *Salvadora persica* which was common by the lake shore (it is also used by the locals as a tooth brush). This bush has limited use for goats other than shade. This particular species is that it is called Topaz Arab *Colotis amata*. The butterfly is Pan African found from Senegal and Ethiopia to South Africa, however, no-one had recognised that this species occurred in Southern Malawi. There is a population which has two female morphs a pink and white and the closest subspecies being *Colotis. a. crowleyi* occurs on the west coast of Madagascar. The question is what happens in between in Mozambique, which is relevant to this survey. White morphs of *Colotis amata* have since been found in coastal Mozambique, suggesting an ancient connection. We have checked Liwonde and *Colotis amata* also flies there with both female morphs so this should almost certainly be considered a Shire Valley Endemic Butterfly.

No species observed were unique to the area except the salt bush breeding *Colotis amata* ssp nov. which has now subsequently been found in adjacent Mozambique. It is important that this vegetation is preserved. The salt bush appears to be under limited pressure as a useful plant to the marsh side communities.

*Acraea encedon* on *Commelina/Ipomoea*

*Acraea serena* on *Ipomoea*

*Neptis jordani* on Polygonum sp.

*Zizeeria knysna* on a variety of Marsh Side Plants

**Figure 27. Pictures of Butterfly species breeding in the Elephant Marsh (Photos: S. Collins).**

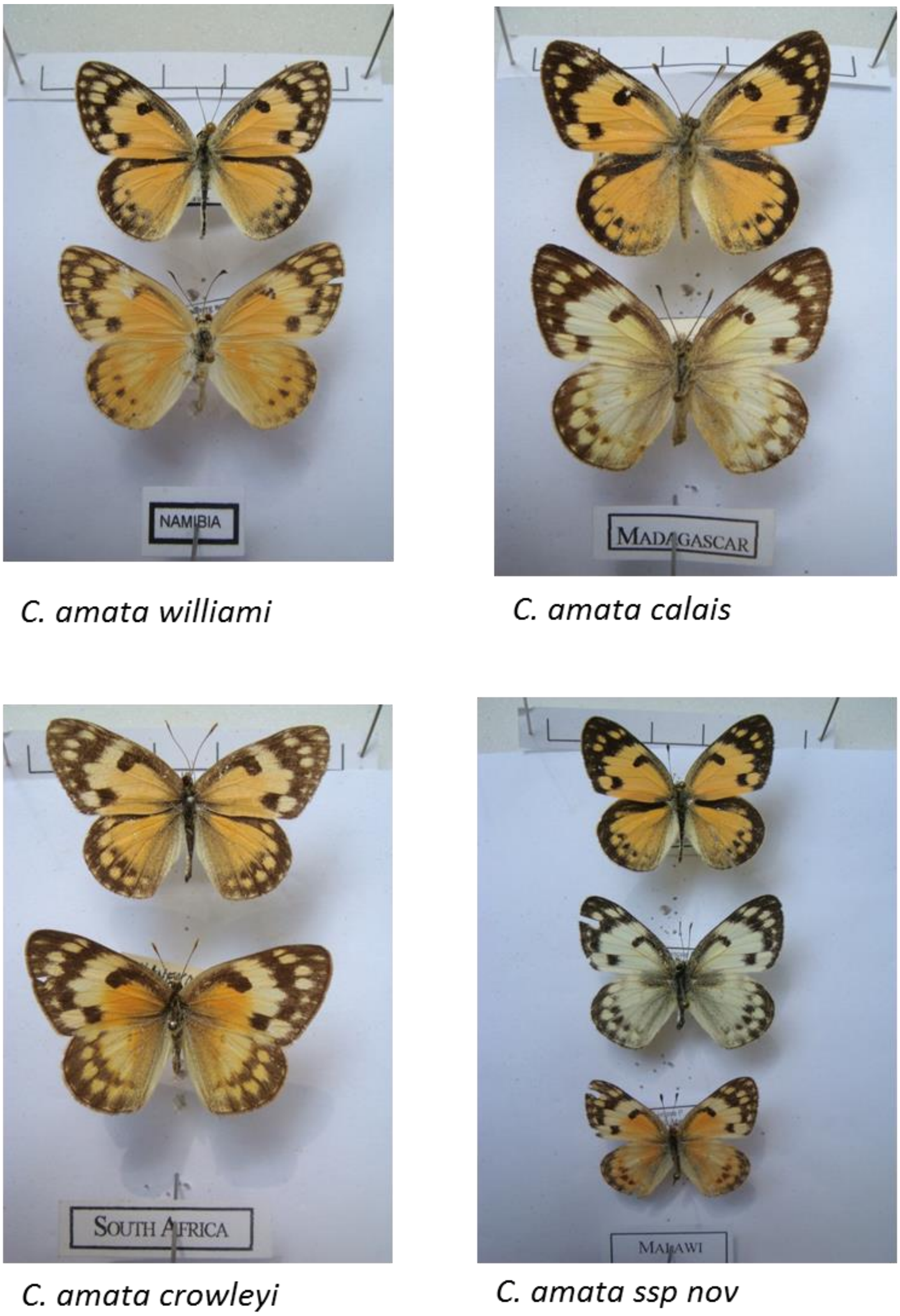


**Figure 28. Colotis amata races in Africa and Madagascar showing the new subspecies to Malawi on bottom right. (Photo: S. Collins).**

## 5.5 Present status of butterfly fauna

The Elephant Marsh area would have supported a fairly diverse butterfly fauna in the past. It is estimated that around 150 species (25% of all species in Malawi) would have been found around the Elephant Marsh area prior to the settlement of the area. The findings of this study survey suggested that there has been significant degradation of habitats and loss of butterfly fauna. The degradation of the Marsh will have resulted in the disappearance of many species, and species numbers in the more densely populated areas will remain low. The intense population pressure around the edge of the Elephant Marsh has left only one place at Kaombe in the south-western corner of the Marsh with any semblance of the original butterfly populations. The rest of the margins of the marshes were heavily cultivated with extensive agricultural activity witnessed during the short trip.

The marsh area around Kaombe would fit into Class C/D (40-80% similar to natural conditions). On the eastern side of the marsh, the butterfly fauna is significantly modified and would be assigned to Class F (<20% natural). Overall, the Elephant Marsh is categorised as being in an E class for butterflies.

# 6 REPTILES AND AMPHIBIANS

## 6.1 Introduction

Amphibians are well represented in sub-Saharan Africa, where approximately 600 species have been recorded. Amphibians are of increasing scientific concern as global reports of declining amphibian populations continue to increase. Although there is no consensus on a single cause for this phenomenon, there is general agreement that the declines in many areas, even in pristine protected parks, are significant and do not represent simple cyclic events. Frogs have been aptly called bio-indicator species, whose abundance and diversity is a reflection of the general health and well-being of aquatic ecosystems. They are important components of wetland systems, particularly ephemeral systems in which fish are either excluded or of minor importance. In these habitats, they can be dominant predators of invertebrates, many of which may impact significantly on humans (e.g. as vectors of disease, such as mosquitoes and bilharzias snails) or their livestock and/or crops.

Reptiles also form a significant component of vertebrate faunas in Africa. With the exception of land tortoises, all terrestrial reptiles are carnivorous, although some larger lizards do supplement their diet with vegetable matter in certain seasons. Reptiles therefore play an important role in nutrient cycling within ecosystems, and in population control of their prey items. Most snakes are specialist feeders, taking specific and limited food classes, and this is often reflected in their common names, i.e. egg-eaters, slug-eaters, centipede eaters, etc. They are usually habitat generalists, occupying a wide range of habitats and vegetation types, provided their primary prey is present. In contrast, most lizards take a wide-range of insect prey, and niche separation between sympatric species usually occurs via habitat selection and/or diel activity (e.g. most geckos are nocturnal). Congeneric species especially occupy different habitats that are determined more by the habitat physical and substrate characteristics rather than the presence of specific plants and/or soil.

The herpetofauna of Malawi in general is not well-known, and has not been recently reviewed. Mercurio (2011), in his review of Malawi amphibians, noted:

> "*After 145 years of herpetological studies with about 50 scientific publications only, the status of knowledge of amphibians and reptiles of Malawi….. is still rudimentary*."

There is fuller documentation for amphibians than reptiles, with a number of monographic reviews of the country's frogs, either at a national level (e.g. Stewart 1967, Mercurio 2011) or as part of larger regional compilations (Poynton & Broadley 1985-1991; Channing 2002). There is no comparable national review of Malawian reptiles, although local surveys and summaries exist (e.g. Loveridge 1953a-c, Stevens 1974, Broadley 2000, etc.). The need for an updated assessment of the diversity and conservation status of reptiles and amphibians of Malawi is essential.

The first specimens collected in the Lower Shire Valley were obtained by Dr Kirk while on the Livingstone expedition (Günther 1864). Loveridge (1953a,b) reported on an expedition to Nyasaland, but did not visit the Elephant Marsh. The snakes of Malawi were covered by Sweeney (1961), whilst Stevens (1974) published an annotated checklist covering the herpetofauna of south-eastern Malawi.

There are few historical herpetological surveys within the Elephant Marsh or its surroundings. Loveridge (1953c) documented a herpetological collection made by the Berner-Carr Entomological Survey of the Shire valley in 1952, and included 15 amphibians and 14 reptiles. Blaylock (1963) reported on two trips (1961-2) to the lower Shire River, including the capture of 163 snakes in 14 days from a camp 10 km upstream from Chiromo. The habitat comprised low scrub next to the swamp and included (taxonomy updated): 97 Western Green Snake *Philothamnus angolensis*, 31 Olive Grass Snakes *Psammophis mossambicus*, 10 Spotted Bush Snake *Philothamnus semivariegatus*, 4 Stripe-bellied Sand Snake *Psammophis orientalis*, 4 Brown House Snake *Boaedon capensis*, 3 Semiornate Snakes *Meizodon semiornata*, and single specimens of Mozambique Spitting Cobra *Naja mossambica*, Olive Marsh Snake *Natriciteres olivaceus*, Rhombic Egg-eater *Dasypelis scabra*, and the Zambezi Blind Snake *Afrotyphlops mucruso*. Other herpetofauna recorded included the reed frog *Hyperolius marmoratus*, and the lizards *Trachylepis striata, T. varia* and *Chamaeleo dilepis*. At Tengani in the lower Shire Valley below Chiromo *Philothamnus semivariegatus*, *Psammophis orientalis,* the Puff-adder *Bitis arietans*, the Snouted Cobra *Naja annulifera*, and the second Shire record of the Floodplain Viper were also collected. Broadley (1996) reported on a small herpetological collection from the Elephant Marsh (quarter degree square 1634Bd; western edge of the Elephant Marsh near the boundary of the Lengwe Game reserve). It included the first record from Malawi and north of the Zambezi of the water snake *Lycodonomorphus obscuriventris*, and prompted Broadley to raise it to a full species (it was previously a subspecies of *L. whytei*). It remains the only Malawi record of this rare snake. Other species from the Elephant Marsh included: the frogs *Xenopus muelleri, Amietia angolensis* (= *A. quecketti* see below), *Ptychadena anchietae, Phrynobatrachus mababiensis, Afrixalus brachycnemis* complex (= *A. crotalus*) and *A. fornasinii*; and the snakes *Natriciteres olivacea* and *Crotaphopeltis hotamboeia.* The herpetofauna of the entire Zambezi drainage basin was summarised by Broadley (2000), including a summary of the reptiles and amphibians from the lower Shire valley. His summary is incorporated into Tables 24 and 25, below.

## 6.2 Survey methods

Two short field surveys on the study area were conducted. The first occurred for five days (5-9 July 2015) during the dry season. A wet season survey was undertaken for five days (17-21 January 2016). All surveys used visual encounter survey methods. Diurnal searches involved active search of specific microhabitats, particularly beneath cover such as decaying logs or mats of vegetation. Nocturnal surveys for amphibians were undertaken in wetlands and surrounding woodland. Advertisement calls were compared with library of southern African frogs calls (Du Preez & Carruthers 2009). Specimens were identified by an experienced observer, and species identification confirmed from comparison with detailed field guides (Broadley 1983, Branch 1998, Channing 2002, Broadley *et al.* 2003, Du Preez & Carruthers 2009, Mercurio 2011).

Herpetofaunal diversity and current nomenclature are based on global on-line checklists: amphibians (Frost 2016) and reptiles (Uetz 2016), as well as a review of the existing herpetological literature of the region. National checklists for amphibians and reptiles extracted from these databases were assessed for accuracy. Both global databases are conservative and reflect recent taxonomic changes only after a lag phase to assess the response of the herpetofaunal community.

Where recent changes have not been adopted by either global database, these are annotated and noted below. These refined databases were compared and contrasted with a number of recent national and regional summaries (e.g. Mazibuko 2005, Government of Malawi 2014, Mercurio 2011, Broadley 2000). They are discussed in fuller detail below when assessing the results of the faunal surveys.

### 6.2.1 Trap arrays.

Due to time constraints surveying the extensive Elephant Marsh no trap arrays were employed during the dry season survey. The use of trap arrays was also constrained by security issues as they needed to be placed in protected areas where the traps would remain intact and functional. Standard straight trap arrays were used in the wet season survey and each trap array consisted of a single 30 m long and 50 cm high drift fence, with eight two-way funnel traps placed at regular intervals on adjacent sides of the fence. Placement and alignment of fence lines was arranged to maximise proximity to shelters and habitats preferred by herpetofauna, e.g. along drainage lines, beside water courses, and accumulations of debris, etc. The trap lines were checked in the early morning and captured specimen identified, retained if necessary for confirmation of identification, or released within close proximity to the trap line region.

The protected Nyala Park Reserve on the Illovo Sugarcane property, Chikwawa District, southern Malawi was selected as suitable for trapping. Nyala Park is a small private small reserve (400 ha), well fenced and protected by guards. It is low-lying and situated in the upper floodplain of the Elephant Marsh. It is regionally inundated in the wet season and during flood conditions and is dominated by fever trees *Acacia xanthofolia*. The northern third, bordering the Mwanza River, was covered in sand and silt during the 2015 floods but was recovering from the inundation.

The reserve is managed to remove alien plants, particularly lantana, and numerous small, semi-permanent wetlands occur along drainage lines and a sandbagged canal that runs through the centre of the reserve and is used to return run-off from the irrigated cane fields to the main Shire River. The land rises gently to the south, which is consequently drier and has closed canopy thicket/woodland in which two trap lines were installed for a 5-day, 4-night period.

Trap line 1 was in thicket beside a canal and dam at Main Picnic Site, Nyala Park, Illovo Sugarcane properties, Chikwawa District, southern Malawi (Figure 29 & Figure 31; 16°10'14.6"S, 34°51'40.2"E; 83 m a.m.s.l.). Trap line 2 was in thicket beside drainage canal at Central Bridge, Nyala Park, Illovo Sugarcane properties, Chikwawa District, southern Malawi (Figure 30 & Figure 31; 16°10'11.5"S, 34°51'57.8"E; 81 m a.m.s.l.).

**Figure 29. Wetland Habitat adjacent to Trap line 1 (Photo W. Branch).**

**Figure 30. Fever Tree (*Acacia xantho*folia) woodland and drainage line next to Trap line 2 (Photo W. Branch).**

**Figure 31. Left: Trap line 1 in open understory. Right: Trap line 2 in secondary growth among flood debris (Photo W. Branch).**

### 6.2.2 Conservation assessment

No Red Data Books have been prepared for Malawi's reptiles and amphibians. It has therefore been necessary to make a conservative assessment of potentially threatened species in Malawi by considering their conservation status in Red Data Books from other African countries (e.g. South Africa), and/or their international status (if assessed) in the IUCN Red List of threatened animals. The use of threatened and sensitive species in international trade is controlled by the Convention on International Trade in Endangered Species (CITES), and where Malawi species occur on CITES appendices that control their international trade this is noted.

## 6.3 Survey results

Due to problems of access and time constraints, certain habitats were not adequately surveyed, e.g. those of the central permanent marsh area. Localities in the extensive papyrus beds are difficult to survey using existing methods, especially at night. The lack of suitable transport, i.e. the non-availability of the airboat, during a time-constrained survey was also unfortunate. The savannah-wetland ecotone of the floodplain was more accessible and thus relatively well-surveyed. However, these areas displayed the greatest degree of human impact. These constraints, however, were not serious limitations to the survey, as the un-surveyed habitats, although among the most pristine in the region, are known to contain a relatively depauperate herpetofauna.

### 6.3.1 Trapping results

The trapping arrays successfully captured numerous specimens, but with relatively low species diversity (Table 23). Reptiles, moreover, were scarce, with only two species and three individuals (<10% of total) captured. Two species collected in the trap arrays, i.e. *Xenopus muelleri* and *Crotaphopeltis hotamboeia*, were not observed during general surveys and observations. The commonest species, the Natal Puddle Frog *Phrynobatrachus natalensis*, breeds in the flooded margins of shallow still water, and large breeding choruses were evident in areas adjacent to the trap arrays during the first two days of trapping when rain fell regularly. The last two days of trapping were rain-free, and captures declined over this period and the more aquatic species, e.g. *Xenopus muelleri*, were no longer caught.

**Table 23. Results of the trap array captures.**

| Day | Trap array 1 | No | Trap array 2 | No |
|---|---|---|---|---|
| 1 | *Ptychadena mossambica* | 1 | *Xenopus muelleri* | 2 |
| | *Phrynobatrachus natalensis* | 10 | *Crotaphopeltis hotamboeia* | 1 |
| 2 | *Crotaphopeltis hotamboeia* | 1 | *Phrynobatrachus natalensis* | 3 |
| | *Phrynobatrachus natalensis* | 6 | | |
| | *Xenopus muelleri* | 2 | | |
| 3 | *Phrynobatrachus natalensis* | 5 | *Hemidactylus mabouia* | 1 |
| | | | *Phrynobatrachus natalensis* | 1 |
| 4 | *Phrynobatrachus natalensis* | 5 | Empty | |
| **Totals** | **4 species** | **30** | **4 species** | **8** |

### 6.3.2 Diversity of Malawi's amphibians

Mazibuko (2005) stated that 83 amphibians occurred in Malawi and tabulated these by genus and family, but gave no source documentation or species checklist. The Fifth Conservation Biodiversity report (Government of Malawi 2014) reiterated this number and noted (again without source documentation) that: "About 83 species of amphibians have been recorded in Malawi of which 6 species are endemic. About 12 amphibian species are threatened and 11 species are listed in the IUCN Red Data-list**"**. These summaries are now inaccurate and outdated. The latest review of Malawi amphibians (Mercurio 2011) listed 84 species, including two unidentified species (*Leptopelis* sp. and *Phrynobatrachus* sp.). However, the Shire River and Elephant Marsh were not surveyed during Mecurio's (2011) surveys. Moreover, a number of species have been affected by taxonomic revisions and the description of cryptic taxa. These are summarised here to inform the changes in amphibian taxonomy adopted in this report.

Common toads previously referred to *Amietophrynus* (Mercurio 2011) or *Bufo* (Stevens 1974, Poynton & Broadley 1988, Channing, 2002) are now placed in the revived genus *Sclerophrys* (Ohler & Dubois 2016). Poynton *et al.* (2016) also revised flat-backed toads and revived *S. pusilla* for southern and eastern populations of *S. maculata*, which is now restricted to West Africa.

The taxonomy of sharp-nosed reed frogs (*Hyperolius nasutus* complex) has been revised (Channing *et al.* 2013), with the recognition of four cryptic species in Malawi. These are *H. acuticeps* (since been shown by Ohler & Fretey (2014) to be a junior synonym of *H. microps*), *H. friedemanni*, *H. viridis* and *H. inyangae*. The distributions of these new taxa within Malawi and adjacent countries have still to be resolved, but *H. friedmanni* is currently considered to be restricted to swamps along the shores of Lake Malawi; *H. viridis* is restricted to high grasslands in northern Malawi and adjacent Tanzania; and the distribution of *H. inyangae* is given as the Eastern Highlands of Zimbabwe and northern Malawi (Channing *et al.* 2013). *H. microps*, the replacement name for *H. acuticeps* (Ohler & Fretey 2014) was noted as being restricted to northern Malawi and extreme northern Mozambique (Frost 2016) although Channing *et al.* (2013) recorded *H. acuticeps* from Chongoni Forest Reserve in southern Malawi. *Hyperolius microps* is therefore the name provisionally assigned here to the Elephant Marsh population of frogs previously referred to *H. nasutus*.

The taxonomy of reed frogs of the *Hyperolius marmoratus-viridiflavus* complex is also confused. Mercurio (2011) recognized three taxa in the lower Shire River and Elephant Marsh region, including the two subspecies *H. marmoratus marginatus* and *H. m. taeniatus*, as well as *H. v. albofasciatus.* His maps show extensive overlap among the taxa in the region. *Hyperolius marginatus* is now treated as separate species, with *H. v. albofasciatus* as a synonym (Frost 2016).

The river frog genus *Amietia* has also been partially revised (Pickersgill 2007, Channing & Baptista 2013, Larson *et al.* 2016), with new cryptic taxa identified. However, the status of the genus in Malawi remains problematic. Mercurio (2011) recorded four species in Malawi; *Amietia johnstoni* remains valid and endemic to Mt Mulanje; *A.* cf. *fuscigula* was recorded from the Misuku Mountains, but is now restricted to South Africa with, equivocal, isolated populations in southern Namibia; *A. viridireticulata* was described from Nyika Plateau, northern Malawi (Pickersgill 2007), and extends in adjacent Tanzania. River frogs from the southern half of Malawi were previously referred to *A. angolensis,* but this is now considered to be restricted to Angola. Populations from southern and eastern Africa are known to comprise a number of cryptic species (Channing & Baptista 2013, Larson *et al.* 2016), and specimens from streams draining from the rift slope into the eastern side of the Elephant Marsh are conservatively referred to the recently revived *A. quecketti,* although this remains to be confirmed by genetic analysis.

### 6.3.3 Amphibians collected during surveys

The short survey periods proved relatively successful, with 25 amphibian species recorded during the surveys (Figure 32, Table 24, Figure 33). These represented 73.5% of the known amphibian fauna. Five of these (*Breviceps poweri, Kassina senegalensis, Hyperolius microps, Hildibrandtia ornata*, and *Tomopterna maculata*) were previously unrecorded from the Lower Shire Valley and Elephant Marsh, but known from adjacent regions. Eight species (*Ptychadena mascareniensis, Ptychadena schillukorum, Hyperolius marginatus, Hyperolius pusillus, Leptopelis mossambicus, Leptopelis parbocagii, Kassina maculata and Afrixalus crotalus*) previously recorded from the Lower Shire Valley and Elephant Marsh (Broadley 2000, Channing 2002, Mercurio 2011) were not encountered during the surveys. These species may have been inactive during the survey periods or were overlooked.

### 6.3.4 Possible and problematic amphibians of the Elephant Marsh

Various amphibians are not presently recorded from the Elephant Marsh or Shire River Valley, but occur in relatively close proximity. Small puddle frog species (*Phrynobatrachus*) remain difficult to identify, and Stevens (1974) had assigned a number of puddle frogs from the Shire Valley to *P. gutturosus.* However, this is a West African species and Mercurio (2011) tentatively referred them to *P. rungwensis.* Although this is more likely than a West African species it still involves a considerable southern range extension and requires confirmation before it can be included in the current summary of the amphibian fauna of the Elephant Marsh. The closely related Dwarf Puddle Frog *P. parvulus* has also not been recorded in the Shire River valley, although it known from the Blantyre region and may occur at lower altitude on the rift slopes. Loveridge's (1953c) record of *P. perpalmatus* from the Shire remains unsupported by subsequent collections, and Poynton and Broadley (1985) considered the species to extend from northern Zambia to Sudan. It is not included in the current summary, and probably represents confusion with another species of puddle frog. The Common Platanna *Xenopus laevis* is also widespread in Malawi but remains unrecorded from the Shire River Valley. Mercurio (2011) notes there are no confirmed records of the burrowing frog *Hemisus guineensis* from Malawi, although its presence in neighbouring regions is often used to infer its presence (e.g. Channing 2001).

An updated checklist of amphibians occurring in the Elephant Marsh and adjacent Shire River Valley is presented in Table 24, and documents the 29 amphibian species confirmed from the Lower Shire Valley and Elephant Marsh. As a result of the surveys the amphibian fauna known for the region was increased to 34 species.

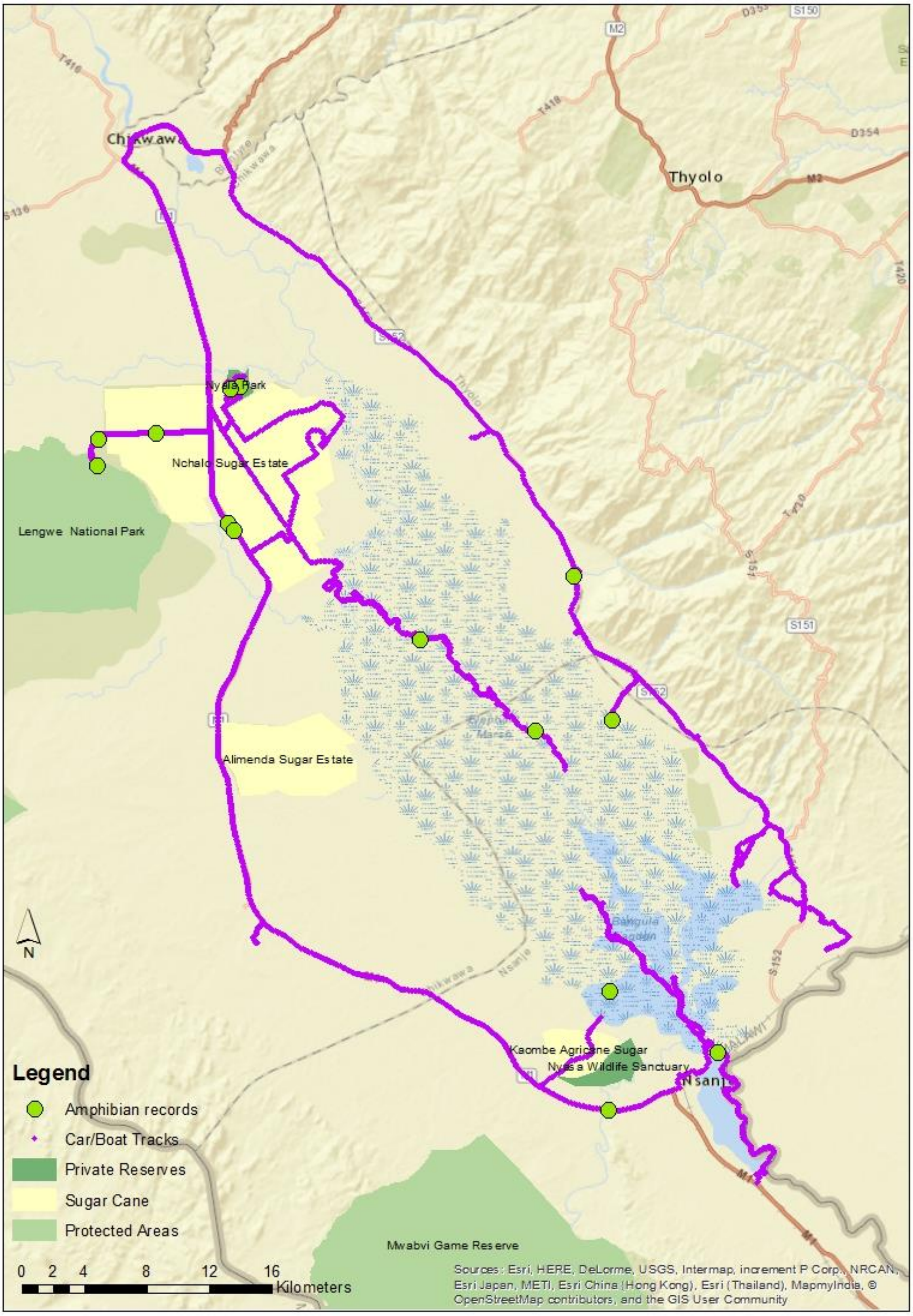


**Figure 32. Locations of amphibians collected and sighted during fieldwork also showing the car and boat tracks of areas that were able to be reached. Details of locations or each species can be found in Appendices 4A & C).**

**Table 24. Updated Checklist of the Amphibians of the Lower Shire River Valley and Elephant Marsh. B = Broadley (2000), L = Loveridge (1953c)**

| Common name | Scientific name | Current survey | In region |
|---|---|---|---|
| **ORDER: ANURA** | | | |
| **FAMILY: ARTHROLEPTIDAE** | | | |
| Common Squeaker | *Arthroleptis stenodactylus* | Y | B, L |
| Mozambique Tree Frog | *Leptopelis mossambicus* | | B |
| Cryptic Tree Frog | *Leptopelis parbocagii* | | B |
| **FAMILY BUFONIDAE** | | | |
| Guttural Toad | *Sclerophrys gutturalis* | Y | B, L |
| Flat-backed Toad | *Sclerophrys pusillus* | Y | B |
| Red Toad | *Schismaderma carens* | Y | L |
| **FAMILY: HEMISOTIDAE** | | | |
| Marbled Snout-burrower | *Hemisus marmoratus* | Y | B |
| **FAMILY: BREVICEPIDAE** | | | |
| Power’s Rain Frog | *Breviceps poweri* | Y | |
| **FAMILY: MICROHYLIDAE** | | | |
| Banded Rubber Frog | *Phrynomantis bifasciatus* | Y | L |
| **FAMILY: PIPIDAE** | | | |
| Tropical Platanna | *Xenopus muelleri* | Y | B, L |
| **FAMILY: HYPEROLIIDAE** | | | |
| Red-legged Kassina | *Kassina maculata* | | B |
| Senegal Kassina | *Kassina senegalensis* | Y | |
| Snoring Spiny Reed Frog | *Afrixalus crotalus* | | B |
| Fornasini’s Spiny Reed Frog | *Afrixalus fornasinii* | Y | B, L |
| Argus Reed Frog | *Hyperolius argus* | Y | B |
| Marbled Reed Frog | *Hyperolius marmoratus* | Y | B, L |
| Margined Reed Frog | *Hyperolius marginatus* | | B |
| Small-eyed Reed Frog | *Hyperolius microps* | Y | |
| Water Lily Reed Frog | *Hyperolius pusillus* | | L |
| Tinker Reed Frog | *Hyperolius tuberilinguis* | Y | B, L |
| **FAMILY: PHRYNOBATRACHIDAE** | | | |
| Eastern Puddle Frog | *Phrynobatrachus acridoides* | Y | B |
| Mababe Puddle Frog | *Phrynobatrachus mababiensis* | Y | B, L |
| Natal Puddle Frog | *Phrynobatrachus natalensis* | Y | B, L |
| **FAMILY: PTYCHADAENIDAE** | | | |
| Ornate Frog | *Hildebrandti ornata* | Y | |
| Anchieta’s Ridged Frog | *Ptychadena anchietae* | Y | B |
| Malagasy Ridged Frog | *Ptychadena mascareniensis* | | B, L |
| Schilluk Ridged Frog | *Ptychadena schillukorum* | | B |
| Mozambique Ridged Frog | *Ptychadena mossambica* | Y | B, L |
| Sharp-nosed Ridged Frog | *Ptychadena oxyrhynchus* | Y | B, L |
| **FAMILY: PYXICEPHALIDAE** | | | |
| Eastern River Frog | *Amietia queckerti* | | |
| Dwarf African Bullfrog | *Pyxicephalus edulis* | Y | B |
| Cryptic Sand Frog | *Tomopterna cryptotis* | Y | B |
| Marbled Sand Frog | *Tomopterna marmorata* | Y | |
| **FAMILY: RHACOPHORIDAE** | | | |
| Grey Foam Nest Frog | *Chiromantis xerampelina* | Y | B |
| | **TOTAL** | **25** | **34 (B 25; L 14)** |

*Ptychadena mossambica* *Phrynomantis bifasciata*

*Pyxicelapus edulis* *Phrynobatrachus natalensis*

*Hyperolius marmoratus taeniatus* *Afrixalus fornasinii*

**Figure 33. Amphibians of the Elephant Marsh and environs (Photos W. Branch).**

### 6.3.5 Diversity of Malawi's reptiles

There have been no national summaries of Malawian reptiles. Mercurio (2011) notes that there are 140+ reptiles in Malawi, and similar but more specific figures are given in Government of Malawi (2014): "145 species of reptiles which belong to 19 families and 72 genera. The majority are snakes of the family Colubridae (43 species), lizards of the families Scincidae (20 species) and Gekkonidae (*sic*) (16 species)." These figures may be inflated (neither contain species lists that can be checked). The Reptile Database (Uetz 2016) lists 129 species for Malawi, but this is also inaccurate for various reasons. It includes 13 species that are no longer considered to occur in the country, mainly due to taxonomic splits (in these instances when allopatric subspecies was raised to specific status, but the original taxon still remained listed; e.g. South African *Cordylus cordylus* and *C. nyikae*, South African *Monopeltis capensis* and *M. rhodesiana*, etc. It also overlooks at least six species that are well known from the country and have been overlooked, e.g. *Lygodactylus capensis, Myriopholis longicauda, Boaedon capensis, Afroedura loveridge, Elasmodactylus tetensis*, and *Varanus albigularis.* Other issue involve recent taxonomic shifts, where new names have been proposed; e.g. *Acanthocercus branchi* (split from *A. atricollis*), *Agama armata* (from *A. hispida*), and *Afrotyphlops mucruso* (from *A. schlegelii*). There have also been numerous family and generic adjustments in recent years that affect the Government of Malawi (2014) figures. It is evident that approximately 130 reptile species are currently recorded from Malawi, of which only some will occur in the Elephant Marsh and its surroundings.

### 6.3.6 Reptiles collected during surveys

The short survey periods were relatively less successful for reptiles than for amphibians and only 21 species were recorded (Figure 34, Table 25, Figure 35). This is only 46.4% of the 58 reptile species known from the Lower Shire Valley and Elephant Marsh. Seven other common species were reliably reported to occur in the region (Table 25; pers. comms. Tony Leiato, Land Preparation Manager, Illovo, November 2015; Bruce Carruthers, Shire River Crocodile Farm, 21 January 2016). Two species were added to the regional herpetofauna during the current surveys; the commensal gecko *Hemidactylus platycephalus* and the small and secretive bark snake *Hemirhaggheris notaeniata*. Loveridge's (1953c) records of *Chondrodactylus turneri* and *Agama armata*, overlooked by Broadley (2000) in his summary of the Lower Shire herpetofana, were confirmed.

An updated checklist of 58 reptiles occurring in the Elephant Marsh and adjacent Shire River Valley is presented in Table 25. It is based on a compilation of the results of the present surveys, as well as a reassessment of the summary of Broadley (2000) and historical literature; e.g. Broadley (2000) overlooked Blaylock's (1963) record of 5 specimens of *Psammophis orientalis* from the lower Shire, and Loveridge's (1953c) records of *Chondrodactylus turneri* and *Agama armata*. In summary the new checklist includes 58 species (about 45% of the reptiles recorded for Malawi). This is an increase from the 52 species recorded by Broadley (2000), resulting from the addition of four species from the region that were overlooked (see above), and two species added to the regional herpetofauna during the current surveys (see above). In summary the reptile fauna is considered to comprise at least 58 species. This is composed of 19 lizards, of which skinks (7 species) are the most diverse; 32 snakes, with colubrids (10) being the most diverse family, and with nine venomous species of which five have caused fatalities; a single crocodilian, and six chelonians of which side-necked pelomedusid terrapins (3) are the most diverse. Representative species and new records for the Elephant Marsh are illustrated in Figure 35.

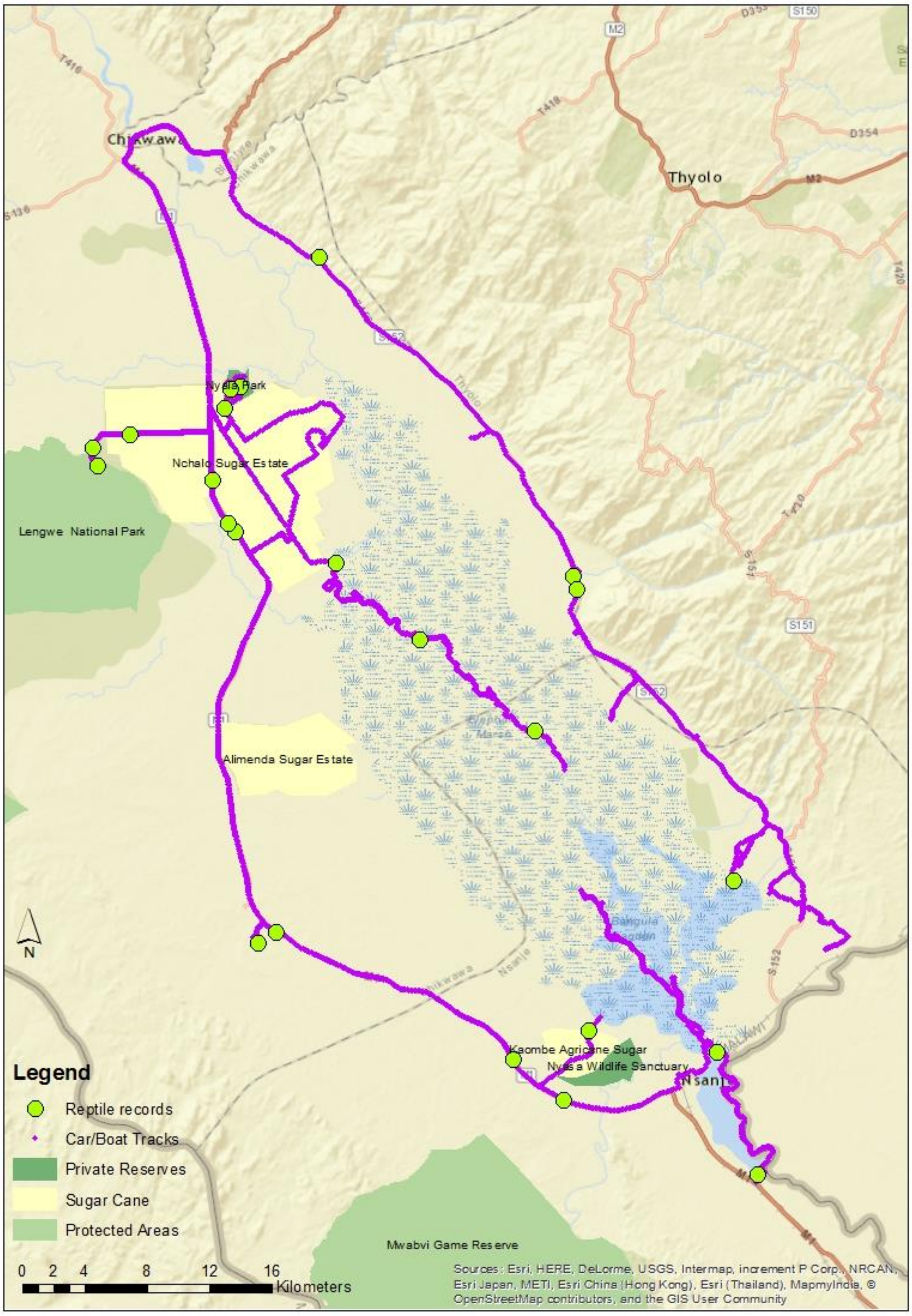


**Figure 34. Locations of reptiles collected and sighted during fieldwork also showing the car and boat tracks of areas that were able to be reached. Details of locations or each species can be found in Appendix 4).**

**Table 25. Updated Checklist of the Reptiles of the Lower Shire River Valley and Elephant Marsh. R = Reported (T. Leiato. pers. comm.), B = Broadley (2000), L = Loveridge (1953c), Bl = Blaylock (1963)**

| Common Name | Scientific Name | Current survey | In region |
|---|---|---|---|
| **LIZARDS** | | | |
| **FAMILY: GEKKONIDAE** | | | |
| Flat-headed House Gecko | *Hemidactylus platycephalus* | Y | |
| Tropical House Gecko | *Hemidactylus mercatorius* | Y | B |
| Common Dwarf Day Gecko | *Lygodactylus capensis* | Y | B, L |
| Turner's Thick-toed Gecko | *Chondrodactylus turneri* | Y | L |
| **FAMILY: VARANIDAE** | | | |
| Nile Monitor | *Varanus niloticus* | Y | B, L |
| **FAMILY: CHAMAELEONIDAE** | | | |
| Flap-necked Chameleon | *Chamaeleo dilepis* | Y | B, L |
| **FAMILY: AGAMIDAE** | | | |
| Ground Agama | *Agama armata* | Y | L |
| Mozambique Agama | *Agama mossambica* | | B |
| **FAMILY: SCINCIDAE** | | | |
| Common Striped Skink | *Trachylepis striata* | Y | B, L |
| Variable Skink | *Trachylepis varia* | Y | B, L |
| Bronze Skink | *Trachylepis boulengeri* | | B |
| Bronze Rock Skink | *Trachylepis lacertiformis* | | B |
| Rainbow Skink | *Trachylepis margaritifer* | Y | B |
| Snake-eyed Skink | *Panaspis* nov. sp. | Y | B |
| **FAMILY: GERRHOSAURIDAE** | | | |
| Black Lined Plated Lizard | *Gerrhosaurus intermedius* | | B, L |
| Yellow-throated Plated Lizard | *Gerrhosaurus flavigularis* | | B |
| Rough-scaled Plated Lizard | *Broadleysaurus major* | | B |
| **FAMILY: AMPHISBAENIDAE** | | | |
| Kalahari Worm Lizard | *Zygaspis quadrifrons* | | B |
| Wavy-tailed Worm Lizard | *Dalophia pistillum* | | B |
| **SNAKES** | | | |
| **FAMILY: TYPHLOPIDAE** | | | |
| Zambezi Beaked Blind Snake | *Afrotyphlops mucruso* | Y | B, L |
| **FAMILY: LEPTOTYPHLOPIDAE** | | | |
| Peters' Thread Snake | *Leptotyphlops scutifrons* | | B |
| **FAMILY: PYTHONIDAE** | | | |
| Southern African Python | *Python natalensis* | R | B |
| **FAMILY:LAMPROPHIIDAE** | | | |
| Plumbeous Centipede Eater | *Aparallactus lunulatus* | | B |
| Bibron's Burrowing Asp | *Atractaspis bibronii* | | B |
| Brown House Snake | *Boaedon capensis* | Y | B, L |
| Dusky-bellied Water Snake | *Lycodonomorphus obscuriventris* | | B |
| Cape Wolf Snake | *Lycophidion capense* | | B |
| Stulmann's Shovel-snout | *Prosymna stuhlmannii* | | B |
| Olive Whip Snake | *Psammophis mossambicus* | Y | B, L |
| Eastern Yellow-bellied Sand Snake | *Psammophis orientalis* | | Bl |
| Beaked Snake | *Rhamphiophis rostratus* | | B |
| Bark Snake | *Hemirhaggheris nototaenia* | Y | |

| Common Name | Scientific Name | Current survey | In region |
|---|---|---|---|
| **FAMILY: COLUBRIDAE** | | | |
| Herald Snake | *Crotaphopeltis hotamboeia* | Y | B |
| Marbled Tree Snake | *Dipsadoboa aulica* | | B |
| Semi-ornate Snake | *Meizodon semiornata* | | B |
| Angola Green Snake | *Philothamnus angolensis* | | B |
| Southeastern Green Snake | *Philothamnus hoplogaster* | | B |
| Variegated Bush Snake | *Philothamnus semivariegatus* | Y | B |
| Tiger Snake | *Telescopus semiannulatus* | R | B |
| Boomslang | *Dispholidus viridis* | | B |
| Oates' Twig Snake | *Thelotornis capensis oatesii* | | B |
| Rhombic Egg-eater | *Dasypeltis scabra* | | B |
| **FAMILY: NATRICIDAE** | | | |
| Forest Marsh Snake | *Natriciteres sylvatica* | | B |
| Olive Marsh Snake | *Natriciteres olivacea* | R | B, L |
| **FAMILY: ELAPIDAE** | | | |
| Boulenger's Garter Snake | *Elapsoidea boulengeri* | | B |
| Snouted Cobra | *Naja annulata* | Y | B |
| Mozambique Spitting Cobra | *Naja mossambica* | Y | B |
| Black Mamba | *Dendroaspis polylepis* | R | |
| **FAMILY: VIPERIDAE** | | | |
| Snouted Night Adder | *Causus defilippii* | | B |
| Puff Adder | *Bitis arietans arietans* | R | B, L |
| Swamp Viper | *Proatheris superciliaris* | | B |
| **CROCODILES: CROCODYLIDAE** | | | |
| Nile Crocodile | *Crocodylus niloticus* | Y | B |
| **CHELONIANS** | | | |
| **FAMILY: TESTUDINIDAE** | | | |
| Speck's Hingeback Tortoise | *Kinixys spekii* | | B |
| **FAMILY: TRIONYCHIDAE** | | | |
| Zambezi Soft-shelled Terrapin | *Cycloderma frenatum* | R | B |
| **FAMILY: PELOMEDUSIDAE** | | | |
| Helmeted Terrapin | *Pelomedusa subrufa* | R | B |
| Yellow-bellied Hinged Terrapin | *Pelusios castanoides* | | B |
| Pan Hinged Terrapin | *Pelusios subniger* | Y | B |
| Serrated Hinged Terrapin | *Pelusios sinuatus* | | B, L |
| | **TOTALS** | **21 (R, 7)** | **58 (B 52, L 14)** |

*Hemirhaggheris nototaenia* *Afrotyphlops mucruso*

*Crotaphopeltis hotamboeia* *Agama armata*

*Hemidactylus platycephalus* *Lygodactylus capensis*

**Figure 35. Reptiles of the Elephant Marsh and environs (Photos W. Branch).**

# 6.4 Description of present-day biota

## 6.4.1 Threatened Malawi amphibians

The Fifth Conservation Biodiversity report (Government of Malawi 2014) notes nationally that "About 12 amphibian species are threatened and 11 species are listed in the IUCN Red Data-list**"**. These are not discussed in the report, although 11 species are listed in Table 26. The identity of the 12th threatened species, missing from the list is not indicated, and the table is taken from an earlier publication (Malawi State of Environment and Outlook Report 2010).

Not all of the listed species are considered threatened, and it is not obvious why three of these species, i.e. *Scolecomorphus kirkii, Hyperolius pictus* and *Hyperolius spinigularis,* are included in the list. All three are considered unthreatened (Least Concern) by the IUCN, and none are endemic to Malawi. Similarly, although the small puddle frog *Phrynobatrachus stewartae* remains listed as Data Deficient in the IUCN Red List (2015) due to its rarity, it is not endemic to Malawi as two of the three known localities occur in Tanzania. The Ukinga puddle frog *Phrynobatrachus ukingensis* also occurs widely, from the Uluguru Mountains in Tanzania to Maroka in southern Malawi, and it remains DD on the IUCN Red List due to its uncertain taxonomic status in relation to *Phrynobatrachus mababiensis* and *P. parvulus* (Poynton and Broadley 1985b, Zimkus *et al.* 2010). Neither of the puddle frogs included on the list is threatened or endemic. The six remaining threatened frog species are montane isolates, of which four are restricted to the Mulanje massif, and therefore have very restricted distributions that are threatened by local habitat destruction. The Mulanje massif is the main 'hotspot' for Malawi amphibians, with 45 species (over half of all species recorded from the country) being recorded in the region (Mercurio 2011). None of these six nationally or globally threatened amphibian species occur in the Lower Shire River valley or in the Elephant Marsh. No Malawi amphibians are affected by international trade and therefore none regulated by the Convention on International Trade in Endangered Species (CITES).

**Table 26. Threatened Amphibians in Malawi (source Government of Malawi 2014). Key: EN (endangered), NT (near threatened), VU (vulnerable), LC (least concerned), DD (data deficient). Source: IUCN, 2016. (non-threatened species highlighted in bold).**

| Scientific Name | English Name | IUCN | Endemicity | Current Localities |
|---|---|---|---|---|
| *Arthroleptis francei* | France's Squeker | EN | Endemic | Mulanje |
| *Arthroleptis reichei* | Eiche's squeaker | NT | | Misuku hills |
| *Mertensophryne nyikae* | Nyika dwarf toad | VU | | Nyika plateau |
| ***Hyperolius pictus*** | **Variable reed frog** | **LC** | | **Nyika plateau** |
| ***Hyperolius spinigularis*** | **Spiny-throated reed frog** | **LC** | | **Mulanje mountain** |
| ***Phrybobatrachus stewartae*** | **Stewart's puddle frog** | **DD** | **Endemic** | |
| ***Phrynobatrachus ukingensis*** | **Ukinga puddle frog** | **DD** | | **Misuku, Rumphi, Zomba** |
| *Amietia johnstoni* | Johnston's river frog | EN | Endemic | Mulanje mountain |
| *Nothophryne broadleyi* | Mongrel frog | EN | | Mulanje mountain |
| ***Scolecomorphus kirkii*** | **Kirk's caecilian** | **LC** | | **Southern Malawi** |
| *Ptychadena broadleyi* | Broadley's ridged frog | EN | Endemic | Mulanje mountain, Zomba plateau |

### 6.4.2 Threatened Malawi reptiles

The Fifth Conservation Biodiversity report (Government of Malawi 2014) lists threatened Malawi reptiles (Government of Malawi 2014) based on an earlier source (Malawi State of Environment and Outlook Report 2010). However, it does not give the exact threatened status, endemicity or CITES listing of the reptiles included, and none of these are listed in the earlier 'source'. Again this summary of threatened reptiles has several mistakes. Although regionally protected from general hunting in Malawi, the Nile Crocodile is listed as Least Concern (IUCN 2016) and is therefore not considered threatened globally or nationally. International trade in all chameleons (Family Chamaeleonidae), monitor lizards (Family Varanidae) and tortoises (Family Testudinidae) is regulated by the CITES, and all chameleons are placed on CITES Appendices II. Of the three chameleons (taxonomy updated) listed as threatened in Malawi (Table 27, Government of Malawi 2014) only one is actually included on the IUCN Red List (2016): *Chamaeleo* (= *Nadzikambia*) *mlanjensis* – Endangered. The other two chameleons, i.e. *Chamaeleo goetzei nyikae* (now *Trioceros goeztei*) and *Rhampholeon nchisiensis*, are both currently considered Least Concern, although the two subspecies of *T. goeztei* not been investigated in a phylogenetic framework, and may be genetically divergent and of specific status.

The conservation status of none of the four remaining species on the 'threatened' list of Malawi reptiles (Table 27), i.e. *Lygodactylus bonsi*, *Melanoseps ater, Proscelotes mlanjensis* and *Dipsadoboa flavida flavida,* has been assessed by IUCN. Three of these taxa are endemic to the Mulanje massif or its surroundings, but two (*Lygodactylus bonsi* and *Proscelotes mlanjensis*) are common in the montane grasslands of Mulanje and are currently unthreatened. The legless skink *Melanoseps ater* is found in scattered locations throughout Malawi and into southern and eastern Tanzania (Broadley *et al.* 2006) and is neither endemic nor threatened. The snake *Dipsadoboa flavida* inhabits golden bamboo thickets in southern Malawi (Rasmussen 1989), and due to its restricted distribution and the heavy exploitation of bamboo by villagers in the region, it is potentially endangered and its conservation status should be assessed.

The official list of threatened Malawi reptiles (Government of Malawi 2014) excludes perhaps the most endangered Malawi species, Chapman's Pygmy Chameleon, which is considered Critically Endangered (IUCN 2016) and possibly extinct at its type locality in the Natundu Hills. This species is assessed as Critically Endangered as it inhabits forest, and the remaining uncleared forest in its range is estimated to comprise two small degraded fragments (average area 0.29 $km^2$) totalling only 0.6 $km^2$. These fragments may not contain viable populations as they appear heavily degraded (Tolley *et al.* 2014). A number of other species of concern, including endemic species or those listed on CITES, also occur in Malawi and are listed in Table 28.

The Zambezi Soft-shelled terrapin *Cycloderma frenaum* is an iconic reptile of the Zambezi and adjacent drainages of southeast Africa (Broadley & Sachsse 2011). Chelonians have become under increasing threat from exploitation, particularly for international trade to Asia (Cheung & Dudgeon 2006), and this has recently extended to Malawian populations of the Zambezi Soft-shelled terrapin (http://www.faceofmalawi.com/2013/11/chinese-managed-turtle-butchery-discovered-on-lake-malawi/; Figure 36).

To regulate and control this potentially unsustainable exploitation the US Fish and Wildlife Service has submitted (2016) the species for inclusion in Cites Appendices II (FWS 2016). Such a proposal has also been recommended to the Malawi conservation authorities (Waterland *et al.* 2015), who noted that: "turtle species in Lake Malawi … being decimated by highly organised transnational syndicates", and a correlation with ivory poachers, where "…a direct link has been established between the core group and the illegal harvesting of turtles in Lake Malawi."

**Figure 36. Turtle butchery, Mangochi, Lake Malawi (Waterland *et al.* 2015)**

There are few records of Soft-shelled terrapins in the lower Shire River and Elephant Marsh, and they were not recorded by Loveridge (1953c) or Blaylock (1963). Fishermen were asked about recent sightings during the fieldwork, but none had seen any. However, a number were seen in the Shire River above Chikwawa 30 years ago (1980), and the last seen 15+ years ago (Tony Leiato, Land Preparation Manager, Illovo; pers. comm. November 2015). The species is known to prefer clean water with sand substrates (Broadley & Sachsse 2011) and the apparent decline in the Shire River may result from increased siltation due to habitat degradation in the headwaters. While it is possible the species has been extirpated from the study area as the last report was from over 15 years ago, this cannot be confirmed without a more comprehensive survey effort.

A small snake-eyed skink *Panaspis* cf *wahlbergii* may represent a new species (Figure 37). The group is known to exhibit high levels of cryptic speciation, with 12 putative new species recently demonstrated (Medicna *et al.* 2016). Typical *P. wahlbergii* is now known to be restricted to the east coast region of South Africa and adjacent southern Mozambique and does not occur north of the Zambezi River. A population in the Mt Mulanje region, to which the Ngabu Farm population (see below) may be related, is known to involve a new species whose conservation status will require further assessment.

**Figure 37. New Snake-eyed Skink (*Panaspis* nov. sp.), Farm Ngabu (Photo W. Branch).**

**Table 27. Threatened Reptiles of Malawi (source Government of Malawi 2014*). * The exact threatened status, endemicity and CITES listing are included here but not given in the report**

| Common Name | Scientific Name | IUCN | Endemic | CITES |
|---|---|---|---|---|
| Nile crocodile | *Crocodylus niloticus* | LC | Yes | II |
| Mulanje Dwarf Chameleon | *Chamaeleo mlanjensis* | E | Yes | II |
| Nyika Dwarf Chameleon | *Chamaeleo goetzei nyikae* | V (?) | Yes | II |
| Pitless Pygmy Chameleon | *Rhampholeon nchisiensis* | LC | | II |
| Bon's Dwarf Day Gecko | *Lygodactylus bonsi* | V (?) | Yes | |
| Black Legless Skink | *Melanoseps ater* | LC | | |
| Arnold's Skink | *Proscelotes mlanjensis* | LC | Yes | |
| Cross-barred Tree Snake | *Dipsadoboa flavida flavida* | V (?) | Yes | |

**Table 28. Additional Reptiles Species of Concern* in Malawi (not in Government of Malawi 2014). * Species of Concern are those species listed in the IUCN Red List (2016), endemic to Malawi, or whose international trade is regulated by CITES listing.**

| Common Name | Scientific Name | IUCN | Endemic | CITES |
|---|---|---|---|---|
| Southern African Python | *Python natalensis* | LC | | II |
| Chapman's Pygmy Chameleon | *Rhampholeon chapmanorum* | CE | Yes | II |
| Sword-nosed Chameleon | *Trioceros melleri* | LC | | II |
| Flap-necked Chameleon | *Chamaeleo dilepis* | LC | | II |
| King Dwarf Day Gecko | *Lygodactylus rex* | LC | Yes | |
| Rock Monitor | *Varanus albigularis* | LC | | II |
| Nile Monitor | *Varanus niloticus* | LC | | II |
| Zambezi Soft-shelled Terrapin | *Cycloderma frenatum* | NT | | |
| Spek's Hingeback Tortoise | *Kinixys spekii* | LC | | II |
| Mulanje Flat Lizard | *Platysaurus mitchelli* | LC | Yes | |

### 6.4.3 Crocodiles

Large Nile crocodiles (>3 m) are still common in the Shire River and Elephant Marsh (Figure 38), and are capable of attacking people. Questions to local fishermen and farmers indicated that all were aware of crocodile attacks in the region and thus took due care near water. Several human deaths a year were stated to occur by villagers on the banks of the lower Shire at Chiromo, and also in the vicinity of the Illovo sugarcane plantation. This contrasted with anecdotal estimates of 200 attacks on people annually, with perhaps 60 deaths a year in the greater Lower Shire area (Kalowekamo 2000). Local people stoically accepted the presence of crocodiles, although people acknowledged that they attempted to kill large specimens following attacks on people or livestock, and crocodile trapping was observed during this study. The main concern for many fishermen, however, was loss of and damage to gill nets set overnight for fish.

**Figure 38. A large (4m), basking Nile Crocodile *Crocodylus niloticus* slips into the River Shire (Photo W. Branch).**

Human-crocodile interactions are varied. They include obvious predator-prey interactions, resulting in human fatalities, and human hunting of crocodiles for meat, skins and eggs. The growth of crocodile farming in the region is an economic investment in the exploitation of crocodile for skins and meat, and currently involves the ongoing collection of eggs from wild nests and adult crocodiles for breeding stock. The Shire River Crocodile Farm farms a total of 18 000 crocodiles for the commercial production of crocodile belly skins (http://www.shirerivercrocodiles.com/). On average 5000 crocodile eggs are collected each year from nests along the Shire River and in the Elephant Marsh. The average nest includes about 39-40 eggs, and this equates to roughly 120 nests per year. Although 76 large breeding females are maintained at the Crocodile Park they do not currently supply sufficient eggs to avoid the off-take of wild eggs (Bruce Carruthers, pers. comm., Jan 2016).

There are no recent details of scientific surveys of crocodile numbers in the Lower Shire. Fergussen (2005) recorded counts of 77 crocodiles on the Lower Shire River from Chiromo bridge to Nsanje (with a density of 1.23/km), and of 104 crocodiles in the Lower Shire River from Chikwawa bridge to Sucoma (with a density of 2.25/km). In comparison, the densities of crocodiles along the upper Shire River in Liwonde National Park (~30km of river with large adjacent marsh areas) are in the order of 7 per kilometre (JK Turpie, pers. obs., 2016).

While it was not possible to undertake comprehensive surveys during this study, the information gathered from the crocodile farm and from previous surveys suggests that there is still a substantial crocodile population present in the marsh. Dedicated monitoring would need to be conducted to establish any trends within the population.

### 6.4.4 Reptile habitat associations

The likely habitat associations of the reptiles in the region are listed below, and are based on their known life histories (Broadley 1983, Branch 1998). Few species are marsh or wetland specialist, and the greatest reptile diversity is associated with the surrounding woodland mosaic. The floodplain also has few specialist species, and is increasing colonised by savanna species opportunistically exploiting newly-opened and drained habitats that result from human impact and development.

#### *6.4.4.1 Savanna/woodland habitats (41 species)*

Lizards: *Hemidactylus platycephalus, Hemidactylus mercatorius, Lygodactylus capensis, Chondrodactylus turneri, Chamaeleo dilepis, Agama armata, Agama mossambica, Trachylepis striata, Trachylepis varia, Trachylepis lacertiformis, Trachylepis margaritifer, Panaspis nov. sp., Gerrhosaurus intermedius, Gerrhosaurus flavigularis, Broadleysaurus major, Zygaspis quadrifrons, Dalophia pistillum. Snakes: Afrotyphlops mucruso, Leptotyphlops scutifrons, Aparallactus lunulatus, Atractaspis bibronii, Boaedon capensis, Lycophidion capense, Prosymna stuhlmannii, Psammophis mossambicus, Psammophis orientalis, Rhamphiophis rostratus, Hemirhaggheris nototaenia, Meizodon semiornata, Philothamnus semivariegatus, Telescopus semiannulatus, Dispholidus viridis, Thelotornis capensis oatesii, Dasypeltis scabra, Elapsoidea boulengeri, Naja annulata, Naja mossambica, Dendroaspis polylepis, Causus defilippii, Bitis arietans.* Tortoise: *Kinixys spekii.*

#### *6.4.4.2 Floodplain (14 species)*

Lizards: *Agama armata, Trachylepis striata, Trachylepis varia, Gerrhosaurus flavigularis.* Snakes: *Boaedon capensis, Crotaphopeltis hotamboeia, Dipsadoboa aulica, Philothamnus angolensis, Philothamnus hoplogaster*, *Naja mossambica, Causus defilippii, Proatheris superciliaris.* Terrapins: *Pelomedusa subrufa, Pelusios subniger.*

#### *6.4.4.3 Marsh and wetlands (15 species)*

Lizards: *Varanus niloticus, Trachylepis boulengeri.* Snakes: *Python natalensis, Lycodonomorphus obscuriventris, Crotaphopeltis hotamboeia, Dipsadoboa aulica, Philothamnus angolensis,* *Philothamnus hoplogaster, Natriciteres sylvatica, Natriciteres olivacea.* Crocodile : *Crocodylus niloticus*. Terrapins: *Cycloderma frenatum, Pelusios castanoides, Pelusios subniger, Pelusios sinuatus.*

## 6.5 Present status of herpetofauna

Prior to human impact the Elephant Marsh would have had more extensive marshy areas, particularly in the surrounding area currently under cultivation. In addition there would have been far more tree cover in the marsh itself and the entire area surrounding the marsh would have comprised tall woodland. Water quantity, quality and flow regulation would have all been higher due to the lack of anthropogenic developments in the catchment. The extensive mammalian megafauna, particularly of elephant, hippo and buffalo, due to their grazing and activity in the marsh would have controlled and limited the development of the currently impenetrable papyrus beds. As noted in the vegetation chapter the river bank along the main stem of the Shire River would have been fringed by large trees. Riparian woodland would have stabilized the river banks against erosion, as well as allowed a corridor for arboreal species. Another important change relates to changes In the 1980s, to the historical course of the Shire River to facilitate cultivation which lead to drier conditions in the floodplain margin.

Unfortunately, the lack of historical detailed surveys of the Elephant Marsh herpetofauna precludes objective assessment of the ‘health’ of reptile and amphibians communities in the region. No population estimates of the historical herpetofauna are available and it is therefore impossible to quantify possible reptile or amphibian declines or even local extirpation. Due to the extensive wetlands still present there is unlikely to have been extensive loss of amphibian biodiversity or numbers. The loss of their predators, such as snakes and large fish, may have led to increased juvenile recruitment as well as declines in adult mortality. However, these would be balanced by the loss of habitat stability resulting from hydrological changes such as increased flooding, greater water turbidity and siltation. The loss of trees, both along the riparian edge as well as marsh margin, may have affected the survival of tree frogs (*Leptopelis* sp.), which were not recorded during the present surveys. Conversely, the extensively modified marsh fringes are dried and have reduced vegetation cover than originally and this may have allowed a toads and puddle frogs to inhabit these areas in greater numbers than previously. It is thus probable that much of the original amphibian diversity in the region remains as healthy populations, and this is indicted by the high percentage (>73%) of the amphibian diversity recorded during the survey.

Anecdotal observations by a long-term (30+ years) resident with an interest in reptiles (Tony Leiato, Land Preparation Manager, Illovo; pers. comm. November 2015) indicated some potential declines in large reptiles. Puffadders were considered once very common in the 1990s in the vicinity of the Illovo sugarcane plantations, but have now become much rarer, whilst the Boomslang (*Dispholidus viridis*), Twig Snake (*Thelotornis capensis*) and Swamp Viper (*Proatheris superciliaris*) have not been seen in the region in the last 30 years, although all were recorded earlier (Loveridge, 1953c; Blaylock, 1963; Broadley 2000). Similarly, the Soft-shelled Terrapin (*Cycloderma frenatum*) was observed in the Shire River above Chikwawa 30 years ago, but has not been seen for over 15 years. The general impression in the field during the field surveys was of reduced reptile density and diversity. Certainly, the likelihood of repeating Blaylock’s (1963) capture of 163 snakes in 14 days upstream from the floodplain upstream from Chiromo now seem unlikely. No specimens of his two dominant species, the Western Green Snake (*Philothamnus angolensis,* 97 specimens) or Olive Grass Snake (*Psammophis mossambicus,* 31 specimens), were even observed during the current surveys. Many of these snakes, e.g. Boomslang. Twig snake and Spotted Bush Snake, are all arboreal and their current rarity or even absence in the Elephant Marsh, may be linked to their visibility (all are diurnal) and the loss of trees. Chameleons were also not recorded during the surveys and, again, their apparent rarity may be linked to tree loss. It is likely that there is a reduction in snake numbers due to the direct persecution by the high numbers of people now living within the marsh, and indirectly from the extensive habitat destruction and frequent fires.

In summary, is is considered that amphibian diversity and populations numbers still reflect in great part that originally existing in the Elephant Marsh. However, reptiles are considered to show reductions in the numbers, and possibly even local extirpation, of arboreal snakes (Boomslang and Twig Snake), larger terrestrial species (Puffadder), and specialised aquatic species (Zambezi Flap-Shelled Terrapin and Floodplain Viper).

# 7 FISH

## 7.1 Introduction

This section presents an assessment of the fish fauna of the Lower Shire, which includes the Elephant Marsh. The aim is to describe the species and taxonomic groups that occur in the system, outline their ecological and conservation significance, identify the key drivers that determine their abundance, and estimate the current state of health of fish biodiversity. The assessment is based primarily on information collected during a survey of the area, but also draws upon the findings of a small number of other studies undertaken in the Lower Shire and Lower Zambezi system.

The Lower Shire sits within the Lower Zambezi ecosystem, ecologically disconnected from the Middle and Upper Shire, and eventually Lake Malawi, to the north by a series of natural and man-made barriers. As a consequence, the fish fauna of the Lower Shire differs markedly from that of the Middle and Upper Shire. Connectivity with the Lower Zambezi to the south is relatively unimpeded, however, and the fish fauna of the area is considered to be largely representative of the rest of the Lower Zambezi ecoregion (Timberlake 1998; Tweddle 2015a).

The level of taxonomic exploration in the Lower Shire is poor. The majority of the published papers and reports fall into one of two broad categories: taxonomic studies and checklists and fishery-related studies. Few taxonomy-focused investigations have been undertaken in the wider Lower Zambezi system since the first major surveys took place in the 1840s (Peters 1868), and a survey of the Zambezi basin wetlands in the late 1990s presents the most comprehensive understanding of the system's ecology to date (Timberlake 1998). There is also a handful of published studies and unpublished technical reports on the fisheries of the Lower Shire, including the Elephant Marsh, resulting from investigations that began in the 1970s (Tweddle 2015b; Tweddle *et al.* 1995; Tweddle *et al.* 1978; Tweddle & Willoughby 1979; Willoughby & Tweddle 1978). The sources listed in Table 29 below have been used for compiling this assessment of fish biodiversity.

**Table 29. Sources used to prepare fish community descriptions and species lists.**

| Source | Location | Data/information | Reference |
|---|---|---|---|
| Biodiversity of the Zambezi Basin | Zambezi basin | Descriptions of the Zambezi River basin and biodiversity data | (Timberlake 2000a; Timberlake 1998) |
| Biodiversity of the Four Corners Area: Technical Reviews Volume Two | Zambezi and Chobe | Descriptions of the Zambezi and Chobe Rivers and biodiversity data | (Timberlake & Childes 2004) |
| The development of a floodplain fishery: Elephant Marsh, Malawi | Lower Shire and Elephant Marsh | Symposium on river and floodplain fisheries | (Tweddle *et al.* 1978) |
| Catch and effort data for the fisheries of the Lower Shire River and associated marshes, 1976-1993 | Lower Shire and Elephant Marsh | Description of fisheries catch and effort information | (Tweddle *et al.* 1995) |
| Annotated checklist of the fish fauna of the River Shire south of the Kapachira Falls | Lower Shire and Elephant Marsh | Annotated fish checklist for the Elephants Marshes | (Tweddle & Willoughby 1979) |
| What factors drive fishery yields in the Lower Shire River, Malawi? | Lower Shire and Elephant Marsh | Description of fisheries and mass mortality events | (Tweddle 2015b) |

## 7.2 Survey methods

Fieldwork was undertaken during 2-13 November 2015. The primary objective of the surveys was to build up a fish species inventory by sampling locations throughout the Elephant Marsh using a combination of catch-based and fisheries-independent methods. A secondary objective of the visit was to develop the skills of the Malawi Department of Fisheries (DoF) in catch sampling and species identification by teaching and working alongside senior DoF officers and local fisheries monitoring staff from the Chikwawa and Nsanje district offices.

Sampling sites represented all four main habitat types found in the Elephant Marsh and were selected while in the field, working within the limitations of accessing some of the more remote areas of the marsh. Sites to the north (Majete Wildlife Reserve), the south (Bangula lagoon) and east (mountain streams) which are outside of the Elephant Marsh, but part of the Lower Shire River system, were also sampled. The locations of fisheries-independent and catch-based sampling sites are shown in Figure 40.

Fresh catches were inspected at 15 landings sites throughout the marsh (see Figure 40). The team coordinated landing sites visits to coincide with the first landings of the day, at approximately 0600 hrs. A list of species observed at each, and across all sites, was compiled and combined with the list generated through fisheries-independent surveys. Local DoF staff accompanied the team during all landing site visits to provide local species names and to facilitate informal interviews with fishers.

Fisheries-independent surveys involved sampling a range of sites with a variety of fishing gears, including scoop nets, seine nets and electric fishing gear (see Figure 39). All fish caught were identified, which was done either in the field or at a later date from photographs or in the lab. At each sampling site fish were photographed, preserved and stored for later visual and genetic analysis; the visual analysis of specimens was completed shortly after the fieldwork visit.

There is no reliable information available to determine abundance for any fish species in the Elephant Marsh. Frame survey fisheries data for 2014-2015 were available from the Chikwawa DoF office, which are suitable for monitoring catch per unit effort (CPUE) of three species/groups recorded in the frame survey. However, these data are not sufficient to estimate abundance as catch coefficients are not known. To the best of our knowledge, no population modelling has been attempted in the last 5-10 years.

**Figure 39. Examples of fisheries-independent sampling using electrofishing in the Wankurumadzi River (left; photo: R. Arthur) and catch-based sampling showing a typical catch displayed at Chisamba beach (right; photo: T. Davies).**

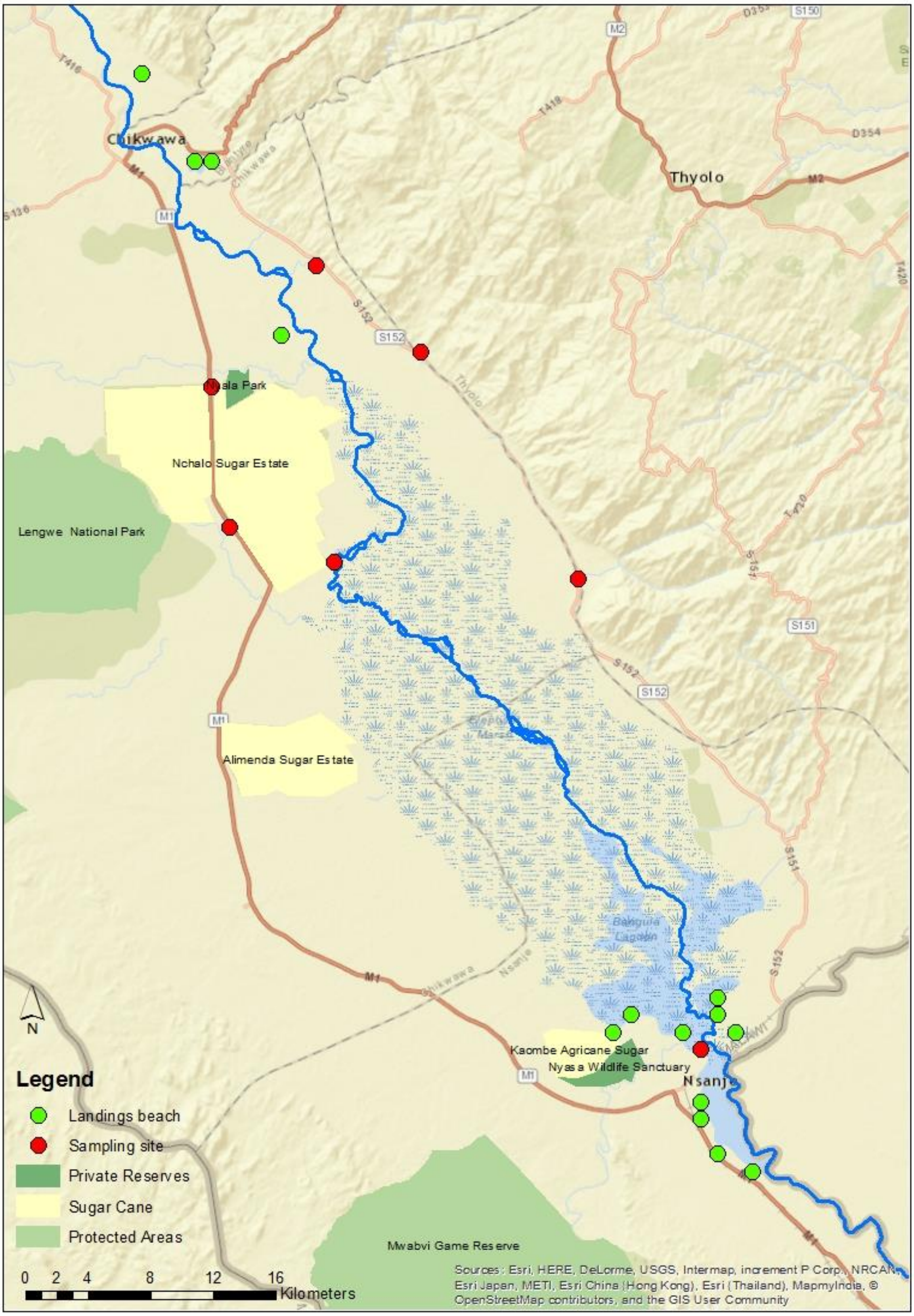


**Figure 40. Locations of landings beaches and sampling sites during fieldwork 2-13 November 2015. Details of each sampling site can be found in Appendix 5.**

## 7.3 Survey results

### 7.3.1 Species list

A total of 52 fish species from 17 families were observed or strongly expected to be resident in the Elephant Marsh (Table 30). This list combines species recorded during the survey in November 2015 (n=43) and species expected with reasonable confidence to be present, but not observed (n=9), based on previous surveys by Tweddle & Willoughby (1979).

Of the species expected but not seen, the common mountain catfish *Amphilius uranoscopus,* was a notable absentee. Tweddle and Willoughby reported this species to be widespread in the east bank streams and in the Wankurumadzi Stream in Majete Wildlife Reserve during the late 1970s. It is possible that this species could be found with additional surveys, or still exists higher upstream in the upper escarpment zone.

One new record not previously reported by Tweddle and Willoughby, and not listed in Table 30, was the non-native mosquitofish *Gambusia affinis*, native to Gulf of Mexico drainages in North America. A single specimen was taken from the Maperera Stream on the East Bank. It is presumed this made its way down from a garden pond in the Blantyre/Limbe area, possibly during floods from the cyclone in early 2015. This species was probably introduced for bio-control prior to 1967. The nature and extent of any environmental impacts to the Elephant Marsh caused by the presence of *G. affinis* are unknown, nor are they well understood from sites elsewhere in Southern Africa where this species has been observed (Ellender & Weyl 2014).

**Table 30. List of species observed in the Elephant Marsh during fieldwork surveys in November 2015, or expected in the area based on surveys by Tweddle and Willoughby (1979), and their current IUCN Red List status. Non-native species are not included.**

| Family | Species | English name | IUCN Red List status |
|---|---|---|---|
| Alestidae | *Hydrocynus vittatus* | Tigerfish | Least Concern |
| | *Micralestes acutidens* | Silver robber | Least Concern |
| Amphiliidae | *Zaireichthys monomotapa* | Eastern sand catlet | Not assessed |
| Anguillidae | *Anguilla bengalensis labiata* | African mottled eel | Near Threatened |
| Chiclidae | *Astatotilapia calliptera* | Eastern happy | Least Concern |
| | *Coptodon rendalli* | Redbreast tilapia | Not assessed |
| | *Oreochromis mossambicus* | Mozambique tilapia | Near Threatened |
| | *Oreochromis placidus* | Black tilapia | Least Concern |
| | *Oreochromis shiranus shiranus* | Shire tilapia | Not assessed |
| | *Pseudocrenilabrus philander* | Southern mouthbrooder | Not assessed |
| Clariidae | *Clarias gariepinus* | Sharptooth catfish | Least Concern |
| | *Clarias ngamensis* | Blunttooth catfish | Least Concern |
| | *Clarias theodorae* | Snake catfish | Least Concern |
| Cyprinidae | *Barbus afrohamiltoni* | Hamilton's barb | Least Concern |
| | *Barbus* cf. *lineomaculatus* | (Unnamed) | Not assessed |
| | *Barbus* cf. *viviparus* | Bowstripe barb | Not assessed |
| | *Barbus haasianus* | Sicklefin barb | Least Concern |
| | *Barbus kerstenii* | Red-spotted barb | Least Concern |
| | *Barbus macrotaenia* | Broadband barb | Least Concern |
| | *Barbus paludinosus* | Straightfin barb | Least Concern |

| Family | Species | English name | IUCN Red List status |
|---|---|---|---|
| | *Barbus radiatus* | Beira barb | Least Concern |
| | *Barbus trimaculatus* | Threespot barb | Least Concern |
| | *Brycinus imberi* | Imberi | Least Concern |
| | *Labeo altivelis* | Hunyani labeo | Least Concern |
| | *Labeo congoro* | Purple labeo | Least Concern |
| | *Labeo cylindricus* | Redeye labeo | Least Concern |
| | *Labeobarbus johnstonii* | Short-barbeled yellowfish | Not assessed |
| | *Opsaridium microcephalum* | Sanjika | Vulnerable |
| | *Opsaridium tweddleorum* | Dwarf sanjika | Least Concern |
| Distichodontidae | *Distichodus mossambicus* | Nkupe | Least Concern |
| | *Distichodus schenga* | Chessa | Least Concern |
| Gobiidae | *Glossogobius callidus* | River goby | Least Concern |
| Malapteruridae | *Malapterurus shirensis* | Electric catfish | Least Concern |
| Mochokidae | *Chiloglanis* sp. nov. | Rock catlet | Not assessed |
| | *Synodontis nebulosus* | Clouded squeaker | Least Concern |
| | *Synodontis zambezensis* | Brown squeaker | Least Concern |
| Mormyridae | *Cyphomyrus discorhynchus* | Zambezi parrotfish | Least Concern |
| | *Marcusenius macrolepidotus* | Bulldog | Least Concern |
| | *Mormyrops anguilloides* | Cornish jack | Least Concern |
| | *Mormyrus longirostris* | Eastern bottlenose | Least Concern |
| Poeciliidae | *Micropanchax katangae* | Striped topminnow | Not assessed |
| Protopteridae | *Protopterus annectens brieni* | Lungfish | Least Concern |
| Schilbeidae | *Schilbe intermedius* | Silver catfish | Least Concern |
| ***Species expected but not seen during fieldwork, based on Tweddle and Willoughby (1979)*** | | | |
| Alestidae | *Hemigrammopetersius barnardi* | Barnard's robber | Least Concern |
| Amphiliidae | *Amphilius uranoscopus* | Common mountain catfish | Least Concern |
| Anabantidae | *Ctenopoma multispinis* | Many spined climbing perch | Least Concern |
| | *Microctenopoma intermedium* | Blackspot climbing perch | Least Concern |
| Clariidae | *Heterobranchus longifilis* | Vundu | Least Concern |
| Cyprinidae | *Barbus atkinsoni* | (Unnamed) | Least Concern |
| | *Barbus* cf. *toppini* | (Unnamed) | Not assessed |
| Gobiidae | *Glossogobius giuris* | Tank goby | Least Concern |
| Poeciliidae | *Micropanchax hutereaui* | Mesh-scaled topminnow | Least Concern |

# 7.4 Description of present-day biota

## 7.4.1 Main fish communities

The Elephant Marsh fish fauna is characterised by a few large, but most mostly small, family groups, the largest being minnows and barbs (5 genera and 18 species of Cyprinidae), followed by cichlids (4 genera and 6 species of Chiclidae); mormyrids (4 species of 4 genera); air-breathing catfishes (3 *Clarias* spp., 1 *Heterobranchus* sp.); mochokid catfishes, African tetras and Poeciliidae (each with 3 species); and a further 10 families represented by two or a single species.

The life histories of the Elephant Marsh fish species, including their fine-scale distribution, habitat preferences and seasonal changes in patterns and abundance, are not very well known. Previous surveys have been too few and intermittent to examine these ecological questions thoroughly and ideally a long-term monitoring programme spread across seasons and years is needed. However, some insight is possible from piece-meal information presented in studies conducted elsewhere in southern Africa, much of which has been summarised in Skelton (2001).

The majority of fish species in the area are widespread in the lower Zambezi region, or beyond, and are adaptable to varied large river and floodplain habitats. Many migrate laterally into floodplains from the tributary rivers to breed during the rainy season, such as the tigerfish *Hydrocynus vittatus* and catfishes. Some species tend to be restricted to specific habitats such as the lungfish *Protopterus annectens brieni* found in marginal swamps and backwaters, and several small cyprinids, e.g. *Barbus haasianus* and *B*. cf. *viviparous* found exclusively in dense vegetation in swamps. Other species have a clear preference for fast-flowing sections of the river and may therefore be restricted to rocky sections where rapids occur, such as the rock catlet *Chiloglanis* sp. nov. and the common mountain catfish *Amphilius uranoscopus*.

In terms of trophic relationships, the tigerfish exerts a dominating influence on the fish fauna throughout the upper entire Zambezi River Basin, including in the Elephant Marsh where it is common in fishery catches (T. Davies, pers. obs.). It is a voracious predator and where it is excluded from rivers by physical barriers, low oxygen levels or shallow water depths there may be significant changes in the composition of the fish communities as a result (Bell-Cross 1974).

### 7.4.2 Species at risk

Most fish species observed or expected in the Elephant Marsh have been assessed in the IUCN Red List – only 10 species (19%) have not been assessed – and the majority are considered to be Least Concern (Table 30). One species, the sanjika *Opsaridium microcephalum*, has been assessed as Vulnerable, and two species, the African mottled eel *Anguilla bengalensis labiate* and the Mozambique tilapia *Oreochromis mossambicus*, are considered to be Near Threatened. Whilst not considered threatened by the IUCN Red List, the widespread lungfish *Protopterus annectens* is restricted to seasonal pools, which are susceptible to land use change and drainage, and so may be at risk locally.

The sanjika is endemic to Lake Malawi, its catchment area and the Lower Shire. The population reduction has been estimated at not less than 30% in the last 10 years, due to a combination of overfishing and habitat degradation (IUCN 2006). Overfishing of adults causes extremely high mortalities during spawning runs, and fish poisoning, although illegal, is widely practised in the Lake Malawi area. It is not known if poisoning also occurs in the Elephant Marsh. Deterioration of spawning grounds due to siltation from soil erosion and changes in river flow is likely to be a relevant concern in the Lower Shire.

The African mottled eel is a widely distributed anguillid common to east and southeast African water systems, although its range and regional abundance has declined by an unknown percentage. In southern Africa, fishing pressure from hook and line catching and poisoning is recognised as a cause of the population decline (IUCN 2012). Barriers to migration also appear to be a factor in the species decline in Zimbabwe, with dams such as the Cabora Bassa and Kariba dams preventing migration (Matiza & Crafter 1994). It is not known, but may be speculated, that the Kapachira hydroelectric power station on the Shire River, upstream of the Elephant Marsh, may limit the available habitat and movement of this species.

The Mozambique tilapia occurs naturally throughout the Lower Zambezi, the Lower Shire and coastal plains from the Zambezi delta to Algoa Bay. It is also widely dispersed beyond this range to inland regions of Southern Africa, including the lower Orange and rivers of Namibia, and has been introduced to tropical and warm temperate water bodies throughout the world. The main threat to this species is hybridisation with the Nile tilapia *Oreochromis niloticus*, which is rapidly spreading throughout the Zambezi and Limpopo systems. Hybridisation is already occurring throughout the northern part of the Mozambique tilapia's range, but probably more than 50% of the locations are not yet affected (IUCN 2007). The Nile tilapia was not observed in the Elephant Marsh during the fish surveys, which may be a positive indication that hybridisation is not yet occurring.

## 7.5 Factors determining community structure and abundance

The dominant process affecting fish generally in the Lower Shire, as in other parts of the Lower Zambezi (Timberlake & Childes 2004), is the seasonal change in water levels and flows associated with the wet (November-April) and dry (May-October) seasons. The onset of rains in late October or November results in increased water flows that peak around February-March. During these seasonal flooding events most fish undergo breeding migrations either upstream, to smaller tributary streams, or laterally into the floodplains and marginal lagoons, returning back to the main channels when water levels fall. The main species typifying the Elephant Marsh, including those of important ecological or livelihoods value, can be placed into four flow-linked fish guilds. TA summary of pertinent life history traits of these species is given in Table 31.

The productivity of fish is closely linked with the flood cycle (Welcomme 1985). The flood-waters bring with them nutrients and sediment, some of which are absorbed by the floodplains. The timing, magnitude and duration of the floods affect the onset of migrations and breeding, the frequency of breeding in a single season, and the growth and survival of young. Successive years of poor rains can also increase the period of time that fish have to stay in the main river channels and can cause a considerable reduction in the numbers of small fish through predation by tigerfish and catfishes. This might be expected to have a knock-on effect to following years as depleted cohorts move through the age classes and reach maturity, although little is known about this aspect in the Zambezi systems (Timberlake & Childes 2004).

Sediment is a natural product of stream erosion; however, the sediment load may be increased by human practices, such as erosion of river banks and hillsides linked to deforestation upstream. Increased sedimentation of rivers can lead to the deterioration of many habitats important to numerous fish species, and ultimately decrease the abundance of sensitive species or even result in local extinctions[9]. An increase in sedimentation blankets the substrate and fills in crevices, as well as increases the turbidity of the water. This can reduce the extent of rocky surfaces for animals and plants to colonise, decreases photosynthetic activity, and lower the oxygen content of the water.

[9] Sedimentation is rated as a primary threat to fishes and molluscs by the IUCN Red List: http://www.iucnredlist.org/initiatives/freshwater/panafrica/threats. Accessed on 19th April 2016.

**Table 31. Fish life history traits pertinent to the modelling of biotic responses. R = river channel, F = floodplain, L = lake, M = marsh.**

| Indicator | | Habitat | | | | Flow response | | Reasons for selection as indicator |
|---|---|---|---|---|---|---|---|---|
| **Flow linked guild** | **Representative spp.** | **R** | **F** | **L** | **M** | **Drought/low** | **High/flood** | |
| Flood-plain migrants | *Oreochromis mossambicus* | | X | X | X | Tend to disappear when floodplain is disconnected from the main channel; in extended dry season recruitment suffers when access to floodplain denied to fry and juveniles | Recruitment suffers from disruption to shallow breeding and juvenile feeding habitats; higher floods might result in stronger year-class strength | Inhabit relatively well oxygenated water bodies that are regularly connected to the main river by flooding (therefore sensitive to the amplitude of flooding that regulates connectivity to the river and extent of inundated floodplain; intolerance of complete anoxia)<br>Breeds in shallow waters; juveniles strongly dependent on shallow areas as feeding areas (therefore vulnerable to rapid changes in water level, temperature effects and phytoplankton abundance)<br>Important fisheries species |
| | *Clarias gariepinus* | X | X | X | X | In extended dry season recruitment suffers when access to floodplain denied to fry and juveniles | Generally resistant; higher floods might result in stronger year-class strength | Undertake lateral migrations onto and off the floodplain, which they use for breeding, nursery grounds and feeding by juvenile and adult fish (therefore sensitive to amplitude and duration of flooding)<br>Important fisheries species; prey species for crocodiles |
| Main channel residents | *Hydrocynus vittatus* | X | X | X | | In extended dry season recruitment suffers when access to flooded areas denied for spawning | Rapid drop in flood level might have a negative effect on larval fish back-migrations into main channel | Longitudinal migrants that also undertake lateral migrations onto and off the floodplain, which they use for breeding, nursery grounds and feeding by juvenile and adult fish (therefore sensitive to amplitude and duration of flooding)<br>Adults occupy clear, fast flowing deep water of the main channel or large lagoons that are connected to the main channel; spawns in floodplains<br>Important predator |
| Demer-sal comm-unity | *Distichodus spp., Mormyrops spp., Labeo spp.* | X | | | | Populations suffer in extreme low or no flow periods | Resistant | Live and breed on gravel or rocky river bed habitats<br>Largely unaffected by anything but extreme physical hydrograph changes (adults susceptible to anoxic waters below the thermocline and eggs/larvae impacted by poor aeration caused by low flow)<br>Important fisheries species |
| Riparian comm-unity | *Barbus spp., Micropanchax spp.* | X | | | | Recruitment suffers when peripheral vegetation is exposed by low flow | Recruitment suffers if riparian habitat is inaccessible in high floods | Strong association with peripheral submerged and emergent vegetation (therefore susceptible to rapid and exaggerated changes in flow that affect riparian habitat)<br>Prey species for birds |

Heavy sedimentation can also fill in refugia for crevice-dwelling species and juveniles. All of these impacts reduce the diversity and biomass of all biota, and among the first fish species to disappear would be rocky habitat specialists such as *Amphilius* and *Chiloglanis* catfishes, mastacembelid eels and certain small minnows.

Small-scale fisheries occur throughout the Elephant Marsh, using four main gear types: gill nets, long lines, cast nets, and fish traps. The majority of the catch is made up of the sharptooth catfish *Clarias gariepinus* and the Mozambique tilapia (M. Manase, Malawi DoF, pers. comm.), although fishers will retain almost all individuals of a reasonable size (> c. 5 cm) including dangerous or difficult to handle species such as the electric catfish *Malapterurus shirensis* (T. Davies, pers. obs.). For most species, all length classes are caught, including fry where mosquito netting is used, which can potentially result in growth overfishing (catching recruits before they contribute to overall biomass). Turpie et al. (1999) reported that commercial catches in the Shire valley (mainly Elephant Marsh) had declined by around 50% between the 1980s and 1990s. This decline was generally supported by fishers at focus groups, who reported that larger fish were increasingly difficult to find and that two key commercial species groups, tilapia and *Labeo* spp., were disappearing from lagoons. This was blamed on 'modern' destructive fishing gears such as fine-mesh drag nets. Fishers at Nsanje, however, reported no change in catches over time. There has been no further attempt in the past decade to assess the sustainability of the Elephant Marsh fisheries. Therefore, whilst there is no evidence to suggest that the notable declines in catch observed in the 1990s have not continued, the influence of fishing on the recent dynamics of the fish community remains unknown.

## 7.6 Present status of ichthyofauna

In its reference state, the Elephant Marsh probably had a broadly similar species composition to today. Vagrants such as the sawfish or Zambezi shark would have been more common globally, but are still likely to have been rare visitors to the upper parts of the Lower Shire. However, population sizes of most species, especially those with fisheries value, would certaintly have been higher overall, but is difficult to know to what extent due to the absence of complete historical or recent baseline data.

The loss of seasonal floodplain habitat to cultivation throughout the marsh is likely to have reduced the extent of available breeding and feeding habitat for many species, and therefore their overall abundance in the Elephant Marsh. However, this change has probably not led to the local extinction of any species, at least in recent decades, as considerable seasonal floodplain habitat still exists.

Similarly, the extensive loss of tall and dense riparian woodland along the river banks has reduced available habitat for dense vegetation specialists (e.g. some small cyprinids), although these species appear to have persisted in the marsh.

There are high suspended sediment loads in the Lower Shire, most likely due to erosion of hillslopes upstream in the Shire basin. The effect of sedimentation on the fish community of the Elephant Marsh has not been investigated, but given that rocky habitat species are still present in the Elephant Marsh, the extent of sedimentation is probably not severe.

Fishing pressure is reasonably high in some parts of the Elephant Marsh (conversely, some areas are probably fished at low intensity due to difficulty in access) and the abundance of some species may be locally suppressed in these areas. Fishing effort would have to be very high throughout the Elephant Marsh as a whole to have driven any species to local extinction, and therefore this is unlikely to have occurred for any resident species. Anecdotal reports suggest that two enigmatic vagrants - the Zambezi shark *Carcharhinus leucas* and the largetooth sawfish *Pristis microdon* - may have once been present in the Elephant Marsh (Tweddle & Willoughby 1979), although there is no evidence that either species has been observed in the lifetime of the current generation fishers (T. Davies, pers. obs.). The absence of these species is most likely due to overfishing or other factors (e.g. barriers) downstream, rather than unsustainable harvesting in the Elephant Marsh itself.

No invasive exotic fish species have been observed in the Elephant Marsh, not including the mosquitofish found in one of the mountain streams on the eastern bank. Importantly, the invasive Nile tilapia was not observed, which may be a positive indication that hybridisation with the Mozambique tilapia is not yet occurring. These two observations, and importantly a lack of others, suggests that the fish community is in a relatively natural state in terms of the total number (and proportion) on non-native species present.

Overall, the state of the fish community, considering both diversity of species and abundance, is probably between 50-70% similar to natural conditions (Class C/D). While the abundance and density of fish species in the Elephant Marsh is unknown, the fish community appears to be similar in terms of species diversity to locations elsewhere in the Zambezi basin (Timberlake 1998; Timberlake & Childes 2004). Changes from the reference state are due primarily to fishing pressure and major changes in riverine habitat over the past 100 years or more. This should be considered a preliminary assessment and the scoring is very much dependent on the extent to which fishing and environemental degradation has depressed fish populations, which remains unknown due to poor time series or missing data.

# 8 BIRDS

## 8.1 Introduction

The primary focus of this avifaunal assessment is on waterbirds, as mandated by the wetland character of Elephant Marsh. In particular, this assessment specifically investigates whether or not Elephant Marsh qualifies as a 'Wetland of International Importance' under the auspices of the Ramsar Convention relevant to its waterbird populations.

*The Birds of Malawi: an atlas and handbook* (Dowsett-Lemaire & Dowsett 2006) provides the most comprehensive recent review of Malawi's avifauna (see also Dowsett-Lemaire 2006 for supplementary notes on this volume). This treatise follows on from a series of earlier handbooks on the country's avifauna (Belcher 1930, Benson 1953, Benson & Benson 1977).

Several early publications cover the avifauna, including the aquatic avifauna, of the lower Shire River area, including the Elephant Marsh or parts thereof (e.g. Percival 1902, Benson 1948, Long 1956, 1960, 1961a, 1962b, 1967, 1974, 1976). These lower Shire publications, however, comprise little more than only partially complete and largely anecdotal annotated checklists of the birds of this region, with little quantified treatment.

One of Malawi's most eminent amateur ornithologists, Dale Hanmer, was based at Nchalo, on the edge of Elephant Marsh, for a 16-year period. The primary focus of her efforts, however, was on the capture ('mist-netting') and ringing of small birds in this region (e.g. Hanmer 1979, 1982a, 1986, 1989a, b), although she also published several studies, including some extending beyond ringing-based investigations, relevant to the larger-bodied waterbirds of the region (e.g. Hanmer 1982b, 1985, 1988, 1989c, 1994, 1997, 1998).

The leading authorities on the Malawian avifauna, Francois Dowsett-Lemaire and Robert Dowsett, conducted a detailed survey of the avifauna of the lower Shire area (Dowsett-Lemaire & Dowsett 2002) but their investigation was largely centred on the three large formally protected areas in this region (Majete Wildlife Reserve, Lengwe National Park and Mwabvi Wildlife Reserve), although some coverage of Elephant Marsh is provided.

Malawi is a signatory to the Ramsar Convention, although only a single wetland has been designated as a Ramsar site to date – Lake Chilwa in 1997 (Dowsett-Lemaire *et al.* 2001; BirdLife International 2002). Twenty-two global 'Important Bird Areas' ('IBAs') have been identified in Malawi, including Lake Chilwa (Dowsett-Lemaire *et al.* 2001). Most of these IBAs focus mainly on the indubitably important Afromontane habitats in Malawi, particularly Afromontane forests. Although some wetland areas exist in many of these IBAs, e.g. Nyika National Park and Liwonde National Park, only two IBAs comprise wetland habitats either primarily (Lake Chilwa) or at least substantially (Vwaza Marsh Wildlife Reserve). The IBA account for Malawi states that Lake Malawi, which is not designated as an IBA, "is too deep to provide significant habitat for wetland species" but that "the more important (partly seasonal) wetlands around Lake Chilwa and in the Shire Valley (Elephant Marsh) still hold large populations of waterbirds." The IBA account, however, does not explain why Elephant Marsh was not designated as an IBA; perhaps the paucity of quantified information on the waterbird populations of this wetland militated against such designation.

Detailed analyses of the biodiversity of the Zambezi Basin wetlands (Timberlake 1998, 2000a, 2000b) included examinations of the avifauna of this broader region, especially the aquatic avifauna. The Lower Shire region, including Elephant Marsh, was contained in these examinations, although no fieldwork was conducted in this area. Timberlake (1998) stated that the compilation of a comprehensive checklist of waterbird species present at Elephant Marsh, as drawn from existing literature, was a high priority. Timberlake (2000a) presents such a list (as compiled by Dale Hanmer), although it covers an area extending strictly beyond the limits of Elephant Marsh, i.e. south to the confluence with the Zambezi River, and hence including Ndinde Marsh. These examinations of the Zambezi Basin wetlands are particularly valuable in placing Elephant Marsh within the highly relevant broader context of this larger holistic and ecologically coherent region. Elephant Marsh is part of this broader Zambezi wetland and waterbird complex, and components of its waterbird populations are likely to move widely between these wetlands as dictated by local and highly dynamic conditions within this zone.

Malawi first took part in the African Waterbird Census (AWC), of The International Waterfowl and Wetlands Research Bureau now Wetlands International, in 1991 (Perennou 1991). The first coverage of the Elephant Marsh as part of these counts was in the following year: January 1992 (Perennou 1992). Counts at the Elephant Marsh have been made subsequently as part of this initiative although rather intermittently and it is likely that only a small proportion of the wetland has been covered during any of these counts.

The common and scientific names, and species ordering, of birds in this report follow that of Dowsett-Lemaire & Dowsett (2006). Although these names and ordering are not in full accordance with the most current global practice (e.g. http://www.worldbirdnames.org/), the advantages of following the treatment as presented in the most up-to-date handbook of the avifauna of Malawi, especially when making direct comparisons with the information in that volume, would seem to outweigh the disadvantages.

Relevant to the waterbird species present at Elephant Marsh, the Ramsar Convention defines as ‘waterbirds’ all species belonging the following families: Podicipedidae (grebes), Pelecanidae (pelicans), Phalacrocoracidae (cormorants), Anhingidae (darters), Ardeidae (herons, egrets and bitterns), Scopidae (Hamerkop), Ciconiidae (storks), Threskiornithidae (ibises and spoonbills), Phoenicopteridae (flamingos), Anatidae (ducks and geese), Rallidae (crakes, rails, gallinules, moorhens and coots), Jacanidae (jacanas), Rostratulidae (painted-snipes), Recurvirostridae (stilts and avocets), Burhinidae (thick-knees or ‘dikkops’), Glareolidae (pratincoles and coursers), Charadriidae (plovers), Scolopacidae (sandpipers), Laridae (gulls), Sternidae (terns) and Rynchopidae (skimmers). Certain members of the following additional families were also considered as waterbirds during this study: Accipitridae (i.e. the aquatic diurnal birds of prey African Fish Eagle, Eurasian and African marsh harriers, and Osprey), Alcedinidae and Cerylidae (aquatic kingfishers, i.e. Malachite, Giant and Pied kingfishers), and Motacillidae (African Pied Wagtail). In addition, the African Waterbird Census counts also considered as waterbirds certain members of the Strigidae (i.e. the aquatic owls Pel’s Fishing Owl and Marsh Owl). These supplementary species, however, cannot be incorporated into the analysis of whether or not Elephant Marsh qualifies as a ‘Wetland of International Importance’ under the auspices of the Ramsar Convention relevant to its waterbird populations.

## 8.2 Field work

The avifauna survey was carried out from 8-14 March 2016. The field investigation of the avifauna of the marsh comprised six primary components, as outlined below.

### 8.2.1 Checklist of the avifauna of the Elephant Marsh area

Lists of all birds encountered (including non-aquatic species) in the project area were compiled. Separate lists were maintained for separate parts of the project area or at least while involved in separate avifaunal sampling efforts some of which overlapped with each other spatially as follows (Figure 41):

1) at Nchalo Sports Club (where we were accommodated) on the edge of Elephant Marsh,
2) at the privately protected Nyala Park reserve on the edge of Nchalo Sugar Estate (which includes an area of wetland linked to side tributary of the main marsh),
3) at the Nchalo 'focus' wetland area on the edge of the main marsh (see below),
4) on Nchalo Sugar Estate generally,
5) at AgriCane's Kaombe Sugar Estate about 38 km to the south-east of Nchalo and also on the edge of Elephant Marsh,
6) at Nyasa Wildlife Sanctuary at Kaombe,
7) while on the microlight flights over the marsh (see below),
8) upper sections of Elephant Marsh using a powerboat; and
9) lower sections of Elephant Marsh using a powerboat (see below).

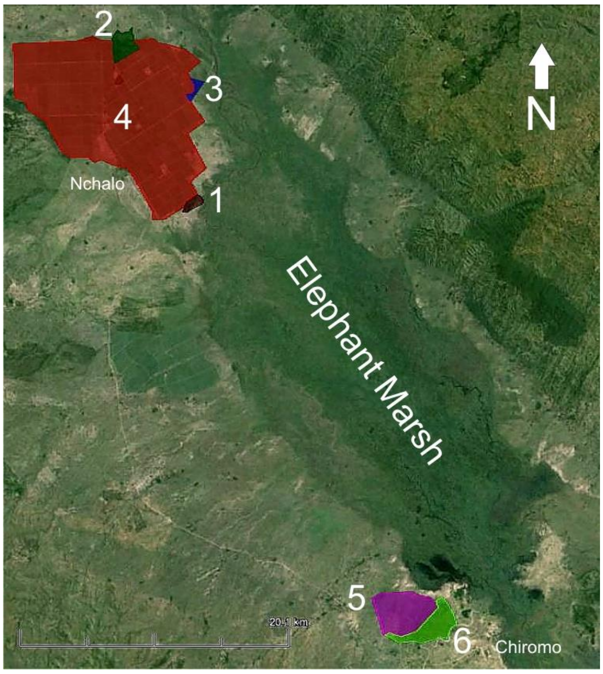


**Figure 41. Six of the nine locations where bird lists were compiled during the course of this study: 1 - Nchalo Sports Club, 2 - Nyala Park, 3 - Nchalo 'focus' wetland, 4 - Nchalo Sugar Estate, 5 – Kaombe Sugar Estate, and 6 - Nyasa Wildlife Sanctuary.**

### 8.2.2 Aerial surveys of Elephant Marsh

Two early morning aerial surveys of Elephant Marsh were made using a microlight aircraft on the consecutive days of 9 and 10 March 2016 (Figure 42, Figure 43). The first flight spanned the period 05h59 – 08h42 (2 hrs 43 mins) and the second 06h36 – 09h16 (2 hrs 40 mins). Weather conditions were ideal for surveying on both days, with calm and clear conditions, and excellent visibility. The observer directly behind the pilot during these flights and headphones allowed direct communication between the observer and the pilot.

**Figure 42. The microlight aircraft used during the waterbird surveys flying over a part of Elephant Marsh.**

Virtually the entire length of the marsh was flown on both flights, indeed the first flight extended south of Chiromo and over wetland areas slightly beyond the traditional limits of Elephant Marsh. The route of the flights was determined while in the air by trying to direct the aircraft over particularly promising stretches of wetland for waterbirds, which largely proved to be the more open areas, including 'lagoons', characterized by exposed sand/mudflats (rare), shallow open water and floating (submerged) vegetation, in contrast to areas uniformly covered with tall emergent vegetation, i.e. hippo grass *Vossia cuspidata*, reeds *Phragmites*, rushes *Typha* and papyrus *Cyperus papyrus*, or highly disturbed by agriculture or human activity. A major pre-determined aim of the survey was to search for any large breeding concentrations of waterbirds in the marsh and so care was taken to try and identify from the air and examine any particularly promising locations in this regard. The precise routes of the two flights were recorded using a GPS that continuously recorded time, speed, altitude and location at five-second intervals throughout both flights. The average speed of the aircraft during these flights was 78 km/h (n = 4 539 speed readings). The average height of the aircraft above ground level during these flights was 100 m (highest elevation was 464 m above ground level; n = 4 528 altitude readings).

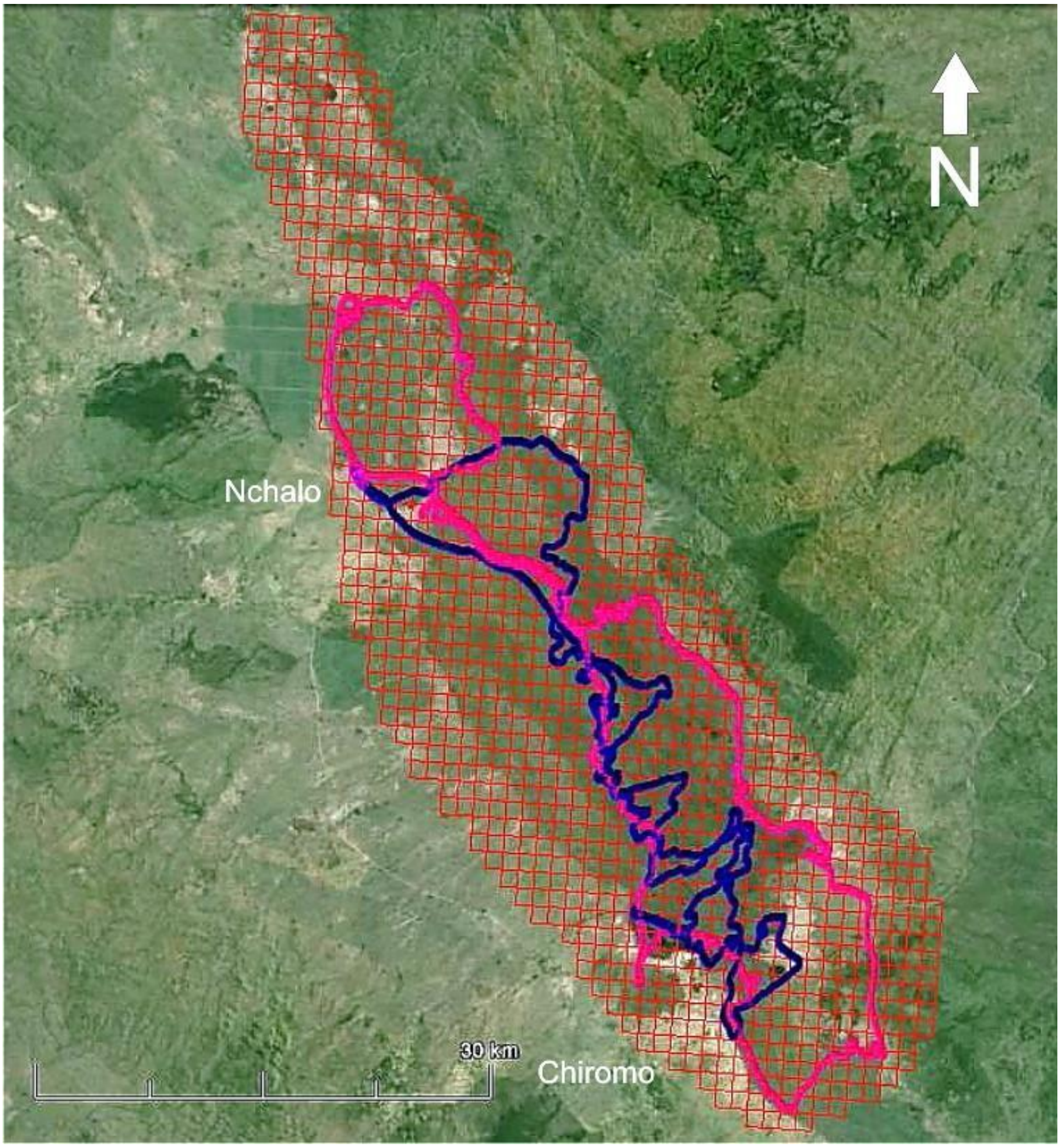


**Figure 43. The routes followed by the 9 March (pink) and 10 March (blue) microlight flights, as well as the grid of 0.01 X 0.01 digital-degree squares laid over the Elephant Marsh area.**

The exposed seating arrangement and relatively unstable nature of the aircraft, coupled with the high speed inherent to any aerial surveying and the fact that only one observer could be transported (in addition to the pilot) rendered the direct counting and recording of waterbirds untenable in real time while in the air, especially when dealing with large and often multi-species flocks of waterbirds. Instead, digital photographs were taken of as many of the waterbirds, and assemblages of waterbirds, as possible during the course of both flights for subsequent identification and counting. Two Canon 60D digital cameras were employed, one with an 18-135 mm zoom lens and the other with a 100-400 mm zoom lens. During the course of the first flight, 518 such photos were taken and during the course of the second 617 photos, i.e. 1 135 photos in total. Of these, 639 photos (56%) showed waterbirds suitable for identification and counting. Many of the remaining photos were devoted to recording other features of the wetland, e.g. hippos, crocodiles, representative images of the wetland, images showing anthropogenic features of interest, etc. Prior to each flight, the time setting of each camera was synchronised with that of the GPS such that the location where each photo was taken could be determined from the GPS-recorded locations (as the GPS was automatically recording locations, and times, every five seconds throughout both flights as mentioned above and the metadata of each digital photo included the time the photo was taken). A grid system of 1 147 numbered grids cells of 0.01 X 0.01 digital degrees was overlain over the entire marsh area which also encompassed the entire area over which the microlight flights were done (Figure 43). Therefore it was possible to allocate each waterbird sighting from the photos from the microlight flights to one of these grid cells. During the course of the two flights, the microlight was flown over 291 of the 1 147 grid cells overlain over the marsh (25%) and waterbirds were photographed in 160 (55%) of the grid cells flown over.

During the process of identifying and counting the waterbirds from the relevant photos and allocating each sighting to a grid cell, care was taken to avoid ‘double-counting’. In particular, in instances where photos of waterbirds were taken in the same grid cell on separate days, or even where a grid cell was flown over more than once on the same day but at different times, only the highest number of an individual waterbird species visible on the photo/photos from a single visit to the grid cell was used.

### 8.2.3 Boat-based survey of the upper Elephant Marsh

On 10 March 2016 a power-boat was used to survey waterbirds of the upper Shire River/Elephant Marsh. The boat travelled from close to the Nchalo Sports Club downstream to where a side channel of the river branched off to the west (Figure 44). The length of the main channel covered was 29.0 km. All waterbirds encountered were identified and counted on both the downstream and return upstream legs of the trip, although only the highest number for each species from one or the other of these two counts was used to avoid ‘double-counting’.

During this trip, we also branched off into two side lagoons of Elephant Marsh (Figure 44, Figure 45 and Figure 46). On the first of these, ‘Upper Shire Lagoon 1’, all waterbirds visible in an area of about 71 ha were identified and counted using binoculars. On the second of these, ‘Upper Shire Lagoon 2’, the same was done over an area of about 98 ha.


**Figure 44. The 29.0 km stretch of the upper Shire River along which waterbirds were counted by powerboat on 10 March 2016, i.e. between the markers labelled "Upper Shire – Main Channel" in the north and "Upper Shire – Main channel/Lagoon 2a" in the south. During this survey deviations into two side lagoons of Elephant Marsh were also made and the waterbirds present there counted, i.e. between the markers "Upper Shire – Lagoon 1a" and "Upper Shire – Lagoon 1b', and "Main channel/Lagoon2a" and "Upper Shire – Lagoon 2b" (see alsoFigure 37 and Figure 38).**

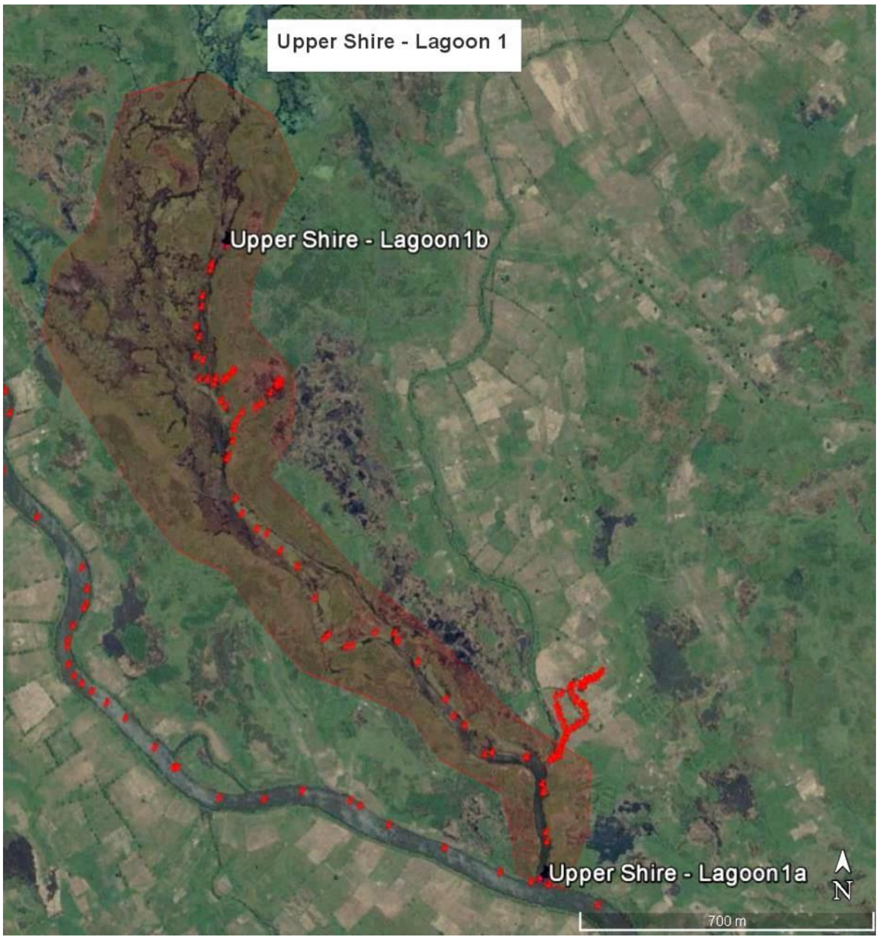


**Figure 45. The 71 ha area (shaded area) of Upper Shire – Lagoon 1 in Elephant Marsh counted for waterbirds during the 10 March powerboat survey. The markers show the route travelled by the powerboat.**


**Figure 46. The 98 ha area (shaded area) of Upper Shire – Lagoon 2 in Elephant Marsh counted for waterbirds during the 10 March powerboat survey. The markers show the route travelled by the powerboat.**

### 8.2.4 Land-based survey of the upper marsh 'focus' wetland

A representative wetland section of upper Elephant Marsh, situated between the east edge of Nchalo Sugar Estate and the western edge of the marsh, was chosen for a waterbird count on the basis of its relative accessibility and proximity to our Nchalo Sports Club base (Figure 47). This area of wetland, which also included a relatively large artificial impoundment, was bounded on several of its edges by roads and another road crossed the wetland between the dam and the wetland proper. The road along the top of the dam was elevated above the remainder of the wetland and allowed particularly good visibility. Counts of the waterbirds present at this wetland were made by walking along the roads on the edge of the wetland and counting the waterbirds visible in it using binoculars and a telescope mounted on a tripod. This wetland was counted over three days (12-14 March 2016), with separate sections being covered on each day. The total size of the area covered was about 63 ha.

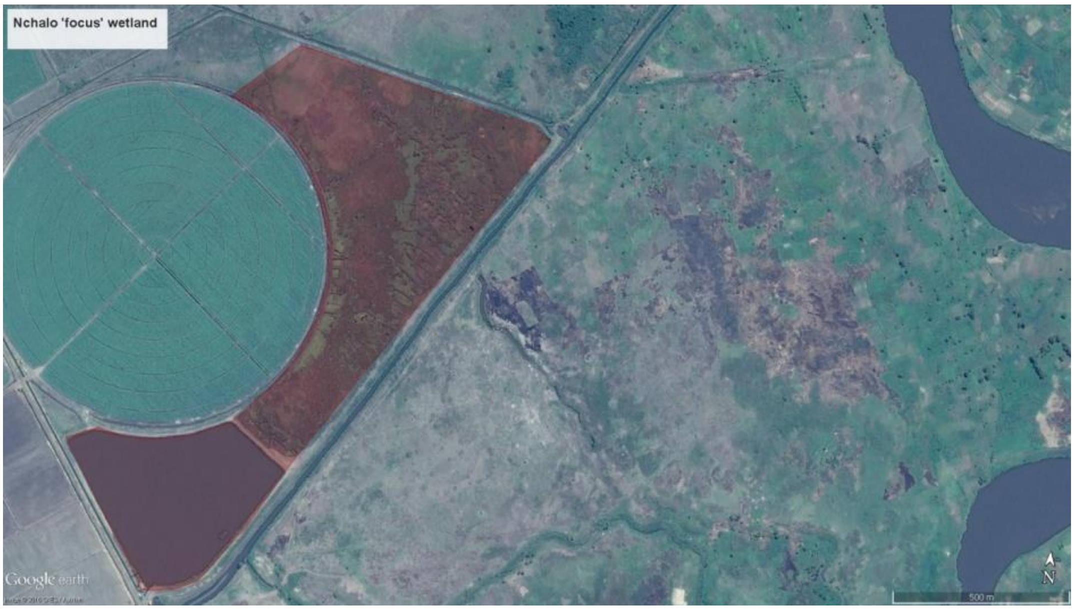


**Figure 47. The Nchalo 'focus' wetland (shaded area) situated between the eastern edge of Nchalo Sugar Estate and the western edge of Elephant Marsh (with part of the main course of the Shire River visible in the far right of the image.**

### 8.2.5 Surveys of the lower Elephant Marsh

Sections of the large, expansive lagoons of the lower Elephant Marsh were examined on 9, 11 and 14 March 2016 (Figure 48). On 9 March a telescope mounted on a tripod was used to count the waterbirds present on the western-most section of lagoon from Viewpoint 1 (Figure 49). On 11 and 14 March a powerboat was steered through the series of lagoons situated east and north-east of the lagoon examined on 9 March (Figure 49). The boat was stopped at intervals to scan from a series of viewpoints (Viewpoints 2-15) and count waterbirds using binoculars and a telescope mounted on a tripod and placed on the bow of the boat. These viewpoints were situated to try and cover as much of the lagoon system as possible without overlapping and 'double-counting' waterbirds. The area of the three areas of lagoon covered in this way was: Lagoons 1 – 866 ha, Lagoons 2 – 198 ha and Lagoons 3 – 1 099 ha, i.e. 2163 ha in total (Figure 49).

**Figure 48. A view over the expansive western-most lagoon at the extreme south of Elephant Marsh.**

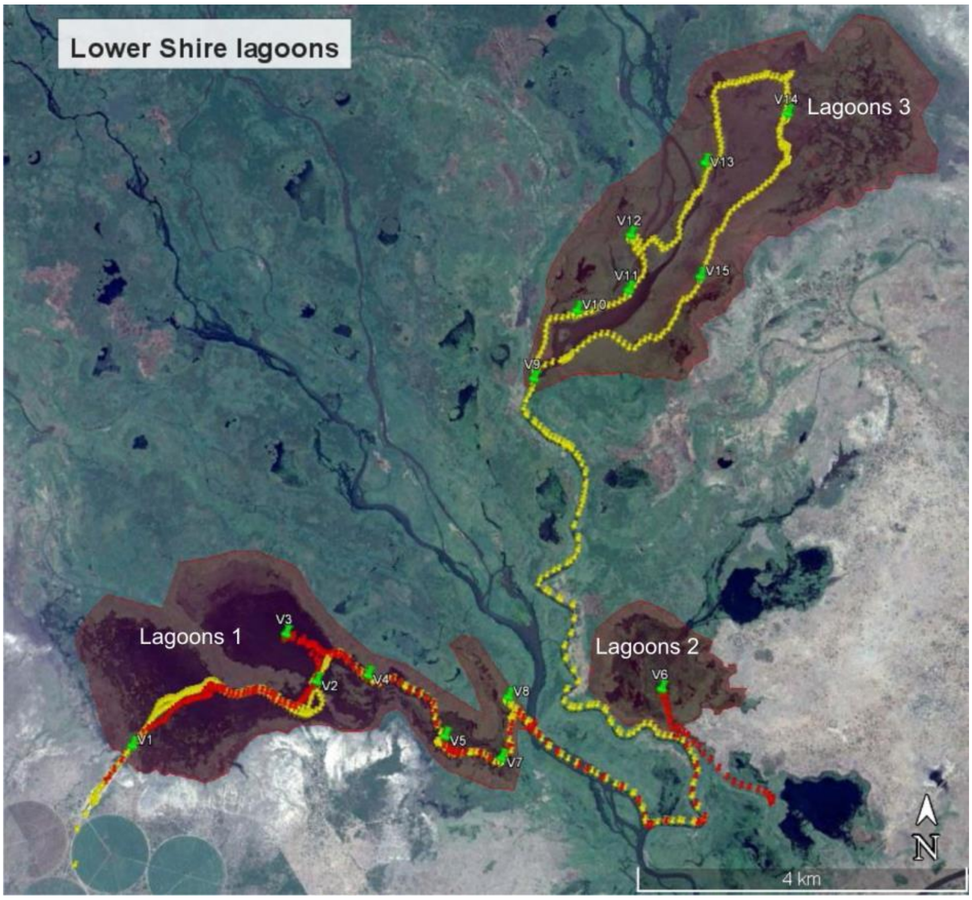


**Figure 49. The three major lagoon sections of the lower Elephant Marsh counted for waterbirds (shaded areas). The westernmost section of lagoon was counted from Viewpoint 1 (V1) on the western edge of the marsh on 9 March. The remaining lagoon sections were surveyed on 11 and 14 March using a powerboat. The 14 viewpoints (V2 – V15) from which waterbirds were counted during the powerboat surveys are shown. Also shown are the routes followed by the powerboat on the 11 March (red) and 14 March (yellow) surveys.**

During the 14 March powerboat survey, the waterbirds encountered along main and side channels of the Shire River flowing through Elephant Marsh were also counted, similar to the counts made along the upper Shire River in the marsh as described above (Figure 50). The length of main channel covered was 2.0 km and the section of side channel was 8.3 km.


**Figure 50. The 2.0 km stretch of the main channel, and 8.3 km stretch of a side channel, of the lower Shire River along which waterbirds were counted by powerboat on 14 March 2016, i.e. respectively between the markers labelled "Main Channel 1" and "Main channel 2/Side channel 1", and "Main channel 2/Side channel 1" and "Side channel 2".**

### 8.2.6 Counts at waterbird communal roosting sites

During the course of field work, five communal roosting sites of waterbirds at Elephant Marsh were noted.

The first of these was in wetland vegetation (reeds) in the upper marsh area close to the Nchalo 'focus' marsh. Waterbirds (cormorants, herons and egrets, and ibises) were counted flying into this roost site on the late afternoon/dusk of 11 March 2016.

The second and third of these were diurnal roosting sites used by Black-crowned Night Herons, one at Nchalo Sports Club and the other situated just east of the mixed-species roost described in the paragraph above.

The fourth communal roost was in several adjacent acacia trees located in the lower Elephant Marsh on the western edge of the lagoons (Figure 53). It was used by a single species, Openbill Stork, and the total number of these storks flying in to roost at the site was counted at dusk on 12 March.

Another apparent Openbill Stork roost, with several birds seen perched on tall baobabs early on the morning of 13 March, was noted on the edge of the upper marsh area just north of Nchalo Sugar Estate but it was not possible to visit this site at dusk to determine the true number of storks using the site due to time constraints. The locations of these five roost sites are shown in Figure 51.

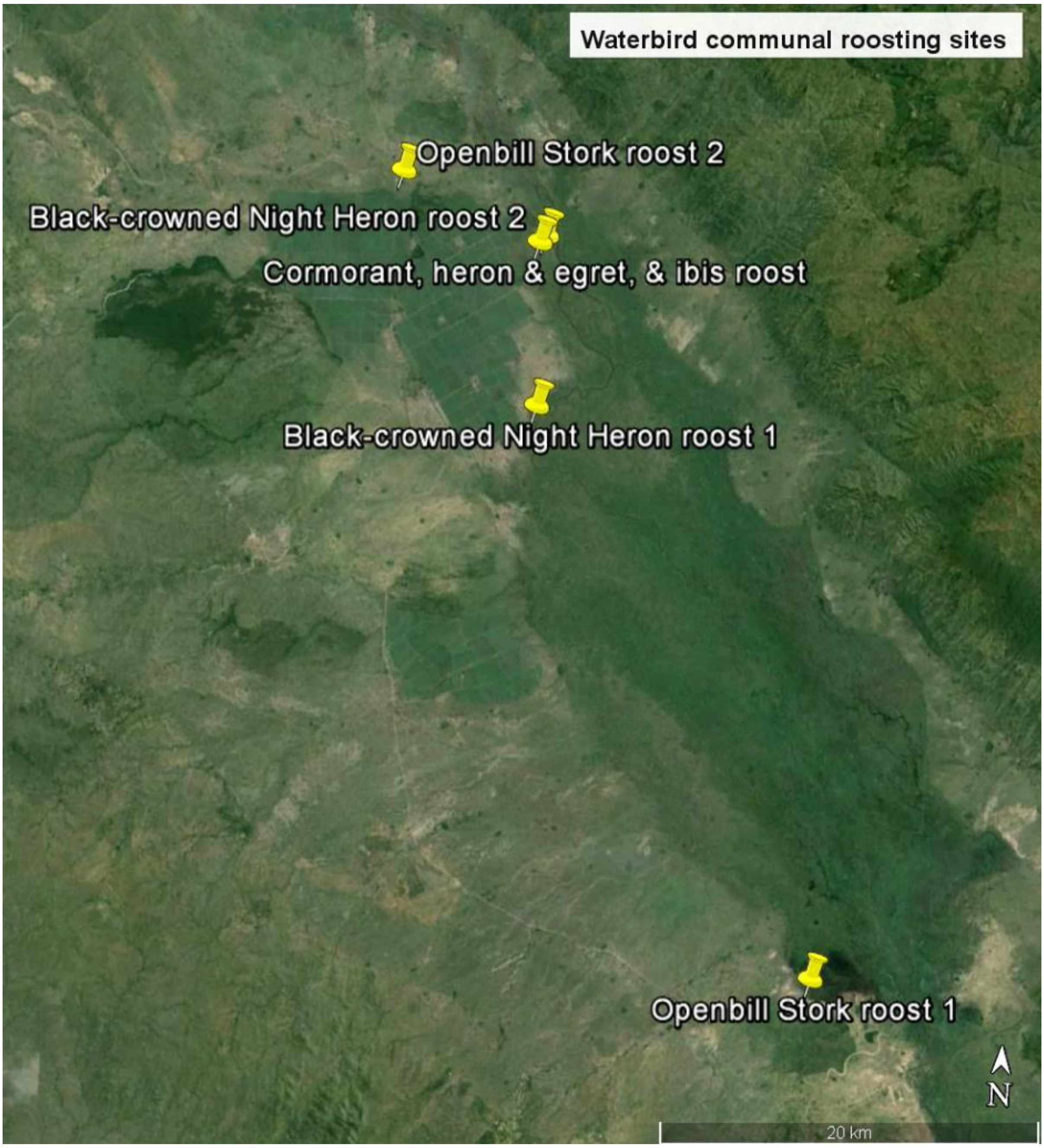


**Figure 51. The location of the five waterbird communal roosting sites located at Elephant Marsh during this study.**

### 8.2.7 African Waterbird Census counts

A total of 25 waterbird counts spanning the period June-July 1991 to January 2016 from the African Waterbird Census covering Elephant Marsh were obtained from John Wilson, the Malawi co-ordinator of the scheme. An additional 13 counts for the 'Sucoma Fish Farm' were also obtained, although these are not used here as they are assumed extraneous to Elephant Marsh proper (although the January 1992 count appears to have the data from Elephant Marsh and Sucoma Fish Farm combined and so is included here). The Sucoma Fish Farms counts are also overall fairly low: 23-866 individuals of 8-35 waterbird species (data for Cattle Egret excluded). The area covered by each of the Elephant Marsh counts is either not described/poorly documented or at best only described in very general terms. It therefore is not possible to determine the exact extent/proportion of Elephant Marsh covered by these counts but it can likely be safely assumed to represent only a small proportion of the entire marsh. These counts were likely concentrated in the southern parts of the marsh, and especially from Kaombe Estate after the establishment of this farm during/shortly after 2009.

## 8.3 Survey results

### 8.3.1 Checklist of the avifauna of the Elephant Marsh area

A total of 199 bird species was recorded in the Elephant Marsh area during the course of this investigation (7-15 March 2016) (Appendix 6A). Of these, 68 species were regarded as waterbirds (Appendix 6A).

### 8.3.2 Aerial surveys of Elephant Marsh

A total of 13 702 individuals of 44 waterbird species were recorded during the two microlight aerial surveys on 9 and 10 March 2016 (Table 32). These can be considered minimum figures due to the care taken to avoid 'double-counting' as discussed previously (not to mention the large areas of the marsh not covered at all during these flights and the many waterbirds, particularly the smaller/more skulking species, that were missed/not photographed in the areas of the marsh that were flown over). Maps showing the locations and numbers of waterbirds counted in the grid cells overlain over the marsh during these flights are presented in Appendix 6A.

**Figure 52. An example of a photograph taken during the microlight surveys of a particularly large mixed flock of waterbirds in the main channel of the Shire River at Elephant Marsh.**

**Table 32. The total numbers of individuals of the 44 waterbird species recorded during the two microlight aerial surveys at Elephant Marsh on 9 and 10 March 2016.**

| Waterbird species | Total | Waterbird species | Total | Waterbird species | Total |
|---|---|---|---|---|---|
| White-breasted Cormorant | 8 | Goliath Heron | 19 | African Jacana | 84 |
| Reed Cormorant | 69 | Yellow-billed Stork | 130 | Black-winged Stilt | 176 |
| African Darter | 48 | Openbill Stork | 1600 | Avocet | 2 |
| Pink-backed Pelican | 50 | Sacred Ibis | 104 | Common Pratincole | 803 |
| Little Bittern | 1 | Glossy Ibis | 41 | Long-toed Plover | 33 |
| Black Crowned Night Heron | 4 | African Spoonbill | 5 | Greenshank | 9 |
| Common Squacco Heron | 1464 | Greater Flamingo | 148 | Wood Sandpiper | 22 |
| Cattle Egret | 1759 | Fulvous Tree Duck | 239 | Little Stint | 475 |
| Black Egret | 2 | White-faced Tree Duck | 2988 | Ruff | 721 |
| Little Egret | 302 | Egyptian Goose | 2 | Palearctic waders | 178 |
| Yellow-billed Egret | 4 | Spur-winged Goose | 112 | Whiskered Tern | 85 |
| Great White Egret | 180 | Knob-billed Duck | 507 | White-winged Tern | 170 |
| Egret spp. | 632 | Red-billed Teal | 169 | Tern spp. | 139 |
| Purple Heron | 29 | Hottentot Teal | 5 | African Skimmer | 112 |
| Grey Heron | 38 | African Fish Eagle | 10 | Pied Kingfisher | 6 |
| Black-headed Heron | 14 | Purple Gallinule | 4 | **TOTAL** | **13 702** |

### 8.3.3 Boat-based survey of the upper Elephant Marsh

A total of 89 individuals of 19 waterbird species were recorded on the 29.0 km powerboat survey of the upper Shire River/Elephant Marsh on 10 March 2016 (Table 33).

**Table 33. The total numbers of individuals of the 19 waterbird species recorded on the powerboat survey of 29.0 km of the upper Shire River/Elephant Marsh on 10 March 2016.**

| Waterbird species | Total | Waterbird species | Total |
|---|---|---|---|
| Cattle Egret | 31 | Purple Gallinule | 1 |
| Green-backed Heron | 1 | African Jacana | 4 |
| Black Egret | 1 | Long-toed Plover | 3 |
| Little Egret | 2 | Greenshank | 1 |
| Grey Heron | 3 | Wood Sandpiper | 2 |
| Black-headed Heron | 4 | Common Sandpiper | 2 |
| Sacred Ibis | 1 | Ruff | 6 |
| Glossy Ibis | 1 | Malachite Kingfisher | 1 |
| White-faced Tree Duck | 19 | Pied Kingfisher | 5 |
| African Marsh Harrier | 1 | **TOTAL** | **89** |

An additional 54 individuals of 13 species was recorded on the 71 ha of the first of the two side lagoons also examined during this survey ('Upper Shire Lagoon 1') and 181 individuals of 10 waterbird species on the 98 ha of the second lagoon examined ('Upper Shire Lagoon 2'), i.e. 235 individuals of 17 species in total on these two lagoons (Table 34).

**Table 34. The total numbers of individuals of the 17 waterbird species recorded on the two side lagoons during powerboat survey of the upper Shire River/Elephant Marsh on 10 March 2016.**

| Waterbird species | Upper Shire Lagoon 1 (71 ha) | Upper Shire Lagoon 2 (98 ha) | Upper Shire lagoons total (169 ha) |
|---|---|---|---|
| Reed Cormorant | 2 | | **2** |
| Black-crowned Night Heron | 2 | | **2** |
| Common Squacco Heron | 12 | | **12** |
| Cattle Egret | 1 | 6 | **7** |
| Great White Egret | 2 | | **2** |
| Purple Heron | 3 | 2 | **5** |
| Grey Heron | 1 | 8 | **9** |
| Openbill Stork | 15 | 38 | **53** |
| Sacred Ibis | | 2 | **2** |
| Fulvous Tree Duck | | 50 | **50** |
| White-faced Tree Duck | 8 | 70 | **78** |
| African Fish Eagle | 1 | | **1** |
| Purple Gallinule | | 1 | **1** |
| African Jacana | | 2 | **2** |
| Whiskered Tern | 1 | 2 | **3** |
| Malachite Kingfisher | 4 | | **4** |
| Pied Kingfisher | 2 | | **2** |
| **TOTAL** | **54** | **181** | **235** |

### 8.3.4 Land-based survey of the upper marsh 'focus' wetland

A total of 440 individuals of 33 waterbird species was recorded at the 65 ha of the 'focus' wetland situated in the upper Elephant Marsh area over the period 12—14 March 2016 (Table 35).

**Table 35. The total numbers of individuals of the 33 waterbird species recorded at the 65 ha 'focus' wetland situated in the upper Elephant Marsh area over the period 12—14 March 2016.**

| Waterbird species | Total | Waterbird species | Total | Waterbird species | Total |
|---|---|---|---|---|---|
| Reed Cormorant | 21 | White-faced Tree Duck | 116 | Water Dikkop | 1 |
| Little Bittern | 3 | Spur-winged Goose | 2 | Three-banded Plover | 1 |
| Black-crowned Night Heron | 3 | Knob-billed Duck | 2 | Greenshank | 1 |
| Common Squacco Heron | 31 | Red-billed Teal | 2 | Wood Sandpiper | 22 |
| Green-backed Heron | 3 | African Marsh Harrier | 2 | Common Sandpiper | 2 |
| Black Egret | 14 | Black Crake | 20 | Little Stint | 3 |
| Little Egret | 2 | Purple Gallinule | 6 | Ruff | 1 |
| Great White Egret | 2 | Lesser Gallinule | 6 | Whiskered Tern | 1 |
| Purple Heron | 2 | African Jacana | 122 | Malachite Kingfisher | 9 |
| Grey Heron | 3 | Painted Snipe | 1 | Pied Kingfisher | 24 |
| Hamerkop | 2 | Black-winged Stilt | 2 | **TOTAL** | **440** |
| Openbill Stork | 8 | | | | |

### 8.3.5 Surveys of the lower Elephant Marsh

A total of 7 046 individuals of 52 waterbird species was recorded at the 2 163 ha of lagoons in the lower Elephant Marsh area over the period 11—14 March 2016 (Table 36).

**Table 36. The total numbers of individuals of the 52 waterbird species recorded at the 2163 ha of lagoons in the lower Elephant Marsh area over the period 11—14 March 2016.**

| Waterbird species | Total | Waterbird species | Total | Waterbird species | Total |
|---|---|---|---|---|---|
| White-breasted Cormorant | 13 | Glossy Ibis | 13 | Three-banded Plover | 2 |
| Reed Cormorant | 533 | Fulvous Tree Duck | 38 | Long-toed Plover | 86 |
| African Darter | 30 | White-faced Tree Duck | 164 | Black-tailed Godwit | 1 |
| Pink-backed Pelican | 41 | Spur-winged Goose | 60 | Marsh Sandpiper | 1 |
| Little Bittern | 2 | Hottentot Teal | 1 | Greenshank | 3 |
| Common Squacco Heron | 253 | African Fish Eagle | 13 | Wood Sandpiper | 51 |
| Cattle Egret | 72 | African Marsh Harrier | 3 | Common Sandpiper | 13 |
| Black Egret | 72 | Osprey | 1 | Little Stint | 467 |
| Little Egret | 36 | Black Crake | 14 | Curlew Sandpiper | 200 |
| Yellow-billed Egret | 16 | Purple Gallinule | 44 | Ruff | 14 |
| Great White Egret | 29 | Common Moorhen | 3 | Grey-headed Gull | 8 |
| Purple Heron | 56 | African Jacana | 1343 | Whiskered Tern | 242 |
| Grey Heron | 17 | Lesser Jacana | 31 | White-winged Tern | 431 |
| Goliath Heron | 2 | Painted Snipe | 1 | African Skimmer | 2 |
| Hamerkop | 1 | Black-winged Stilt | 19 | Malachite Kingfisher | 4 |
| Yellow-billed Stork | 9 | Common Pratincole | 50 | Pied Kingfisher | 58 |
| Openbill Stork | 2473 | Ringed Plover | 1 | **TOTAL** | **7046** |
| Sacred Ibis | 8 | Kittlitz's Plover | 1 | | |

The waterbirds of these lagoons were counted from 15 separate viewpoints and the data from each individual viewpoint is presented in Appendix 6C.

A total of 30 individuals of nine waterbird species was recorded during the powerboat survey along the 2.0 km stretch of the main channel, and 105 individuals of 18 species along a 8.3 km stretch of a side channel, i.e. 135 individuals of 20 species along 10.3 km in total, of the lower Shire River flowing through the Elephant Marsh on 14 March 2016 (Table 37).

**Table 37. The total numbers of individuals of the 20 waterbird species recorded during the powerboat survey along the 2.0 km stretch of the main channel and the 8.3 km stretch of a side channel of the lower Shire River flowing through the Elephant Marsh on 14 March 2016.**

| Waterbird species | Lower marsh main channel (2.0 km) | Lower marsh side channel (8.3 km) | Lower marsh channels total (10.3 km) |
|---|---|---|---|
| African Darter | | 3 | **3** |
| Common Squacco Heron | 5 | 1 | **6** |
| Black Egret | | 1 | **1** |
| Little Egret | | 2 | **2** |
| Yellow-billed Egret | | 1 | **1** |
| Great White Egret | 2 | 2 | **4** |
| Purple Heron | 1 | 1 | **2** |
| Grey Heron | 2 | 20 | **22** |
| Yellow-billed Stork | | 1 | **1** |
| Openbill Stork | 7 | 15 | **22** |
| Glossy Ibis | 1 | | **1** |
| White-faced Tree Duck | 10 | 38 | **48** |
| Spur-winged Goose | | 3 | **3** |
| African Fish Eagle | | 4 | **4** |
| African Marsh Harrier | | 2 | **2** |
| African Jacana | | 1 | **1** |
| Black-winged Stilt | 1 | | **1** |
| Long-toed Plover | | 2 | **2** |
| White-winged Tern | 1 | 3 | **4** |
| Pied Kingfisher | | 5 | **5** |
| **TOTAL** | **30** | **105** | **135** |

### 8.3.6 Counts at waterbird communal roosting sites

A total of 3821 individuals of eight waterbird species were counted on the evening of 11 March 2016 at the waterbird communal roosting site in the upper marsh close to the Nchalo ‘focus’ marsh (Table 38).

**Table 38. The numbers of the eight waterbird species counted on the evening of 11 March 2016 at the waterbird communal roosting site in the upper marsh close to the Nchalo 'focus' marsh.**

| Waterbird species | Total |
|---|---|
| Reed Cormorant | 289 |
| Common Squacco Heron | 25 |
| Cattle Egret | 3333 |
| Black Egret | 39 |
| Little Egret | 19 |
| Great White Egret | 9 |
| Purple Heron | 7 |
| Glossy Ibis | 100 |
| **TOTAL** | **3821** |

The number of Black-crowned Night Herons counted leaving the roost site used by this species next to Nchalo Sports Club was in excess of 100 individuals. The numbers of this species counted leaving the roost close to the Nchalo 'focus' marsh on the evening of 11 March was at least 66.

The number of Openbill Storks counted flying into the roost in several adjacent acacia trees located in the lower Elephant Marsh on the western edge of the lagoons on the evening of 12 March was 1036. As discussed earlier, it was not possible to determine the number of Openbill Storks roosting in tall baobabs on the edge of the upper marsh area just north of Nchalo Sugar Estate.

**Figure 53. A section of the Openbill Stork roost on the edge of a lagoon in the lower reaches of Elephant Marsh.**

### 8.3.7 African Waterbird Census counts

The 25 waterbird counts spanning the period June-July 1991 to January 2016 from the African Waterbird Census covering Elephant Marsh have recorded a total of 94 waterbird species (Appendices 6D&E).

Purported records related to six species in the AWC data are not accepted here as they would appear to require further confirmation:

- rather large totals of 150 and 300 White Pelicans were claimed for the January 2015 and January 2016 counts but these were considered more likely to be Pink-backed Pelicans (which were ostensibly not recorded during these two counts, likely due to either mis-identifications or an error in data entry) and they have been so treated here;
- four Slaty Egrets *Egretta vinaceigula* were claimed for the December 2009 count but Dowsett-Lemaire & Dowsett (2006) consider this species unconfirmed for Malawi;
- Five and 400 Black-winged Pratincoles *Glareola nordmanni* were claimed for the February 2014 and January 2015 counts but these were considered more likely to be Common Pratincoles (which were ostensibly not recorded during these two counts, likely due to either mis-identifications or an error in data entry) and they have been so treated here (see also comments in Dowsett-Lemaire & Dowsett 2006 relevant to the respective status of these two species in Malawi);
- Crowned Plovers *Vanellus coronatus* were claimed for the June-July 1991 (one individual) and July 2012 (eight individuals) counts but Dowsett-Lemaire & Dowsett (2006) consider this species unconfirmed for the whole lower Shire River area;
- a single Spotted Sandpiper *Actitis macularius* was claimed for the February 2014 count but this species is unknown from Malawi (Dowsett-Lemaire & Dowsett 2006); and
- 12 Gull-billed Terns *Sterna nilotica* were claimed for the August 2008 count but Dowsett-Lemaire & Dowsett (2006) consider this species unconfirmed for the whole lower Shire River area.

Only two (Eurasian Marsh Harrier and Black-tailed Godwit) of the 68 waterbird species recorded during the March 2016 survey are not included in the 94 species recorded during the AWC counts (and 28 of the confirmed waterbird species recorded during those counts were not recorded during this survey).

Table 39 provides a full list of the 94 waterbird species recorded during the AWC counts, along with the highest (maximum) numbers ever counted during these counts for each individual species. There appears little value in presenting mean or modal numbers for such widely disparate and incomplete counts. This table also reproduces the data from the most recent AWC count (January 2016) as the results of this count contrast strongly with those of earlier counts, specifically in terms of the remarkably high numbers of waterbirds counted, i.e. 14 162 individual waterbirds with the next highest count being of 4292 individuals, as well as in reporting numbers that appear more similar to 'estimates' rather than actual count data. Due to the markedly 'outlying' nature of the January 2016 count data, the maxima for each species in this table are presented both including and excluding the results from that count.

**Table 39. The 94 waterbird species recorded during the 25 African Waterbird Census counts, along with the results of the 'outlying' January 2016 count and the maximum number of individuals counted for each species for all the counts both excluding and including the January 2016 count.**

| Waterbird species | Max excl Jan 16 count | Max incl Jan 16 count | Jan 16 count |
|---|---|---|---|
| Little Grebe | 21 | 95 | 95 |
| White-breasted Cormorant | 27 | 27 | 4 |
| Reed Cormorant | 273 | 1000 | 1000 |
| African Darter | 8 | 8 | 2 |
| White Pelican | 44 | 44 | |
| Pink-backed Pelican | 150 | 300 | 300 |
| Little Bittern | 6 | 8 | 8 |
| Dwarf Bittern | 1 | 1 | |
| Black-crowned Night Heron | 40 | 40 | |
| White-backed Night Heron | 17 | 17 | |
| Common Squacco Heron | 300 | 300 | 120 |
| Rufous-bellied Heron | 1 | 1 | |
| Cattle Egret | 1379 | 1379 | 600 |
| Green-backed Heron | 17 | 17 | 8 |
| Black Egret | 100 | 800 | 800 |
| Little Egret | 1123 | 1123 | 117 |
| Yellow-billed Egret | 238 | 238 | 200 |
| Great White Egret | 28 | 28 | |
| Purple Heron | 26 | 250 | 250 |
| Grey Heron | 18 | 18 | 18 |
| Black-headed Heron | 62 | 62 | |
| Goliath Heron | 6 | 6 | 2 |
| Hamerkop | 7 | 35 | 35 |
| Yellow-billed Stork | 32 | 32 | 18 |
| Openbill Stork | 270 | 600 | 600 |
| Black Stork | 4 | 4 | |
| Woolly-necked Stork | 17 | 17 | |
| Saddle-billed Stork | 2 | 2 | |
| Marabou Stork | 15 | 15 | |
| Sacred Ibis | 121 | 121 | 4 |
| Glossy Ibis | 102 | 700 | 700 |
| Hadeda Ibis | 6 | 6 | |
| African Spoonbill | 20 | 20 | 6 |
| Greater Flamingo | 2 | 2 | |
| Fulvous Tree Duck | 700 | 700 | 400 |
| White-faced Tree Duck | 2132 | 2132 | 2000 |
| White-backed Duck | 29 | 29 | |
| Egyptian Goose | 7 | 7 | |
| Spur-winged Goose | 78 | 78 | 24 |
| Knob-billed Duck | 105 | 105 | 2 |
| Pygmy Goose | 8 | 8 | |
| Red-billed Teal | 10 | 10 | 6 |
| Hottentot Teal | 28 | 28 | |
| Southern Pochard | 20 | 20 | |
| African Fish Eagle | 8 | 8 | |
| African Marsh Harrier | 8 | 8 | |
| Osprey | 1 | 1 | |

| Waterbird species | Max excl Jan 16 count | Max incl Jan 16 count | Jan 16 count |
|---|---|---|---|
| African Water Rail | 4 | 4 | 2 |
| Corncrake | 1 | 1 | |
| African Crake | 19 | 19 | |
| Black Crake | 78 | 78 | 35 |
| Purple Gallinule | 270 | 270 | 20 |
| Lesser Gallinule | 6 | 6 | |
| Common Moorhen | 15 | 100 | 100 |
| Lesser Moorhen | 18 | 18 | 2 |
| African Finfoot | 1 | 1 | |
| African Jacana | 400 | 400 | 200 |
| Lesser Jacana | 34 | 34 | |
| Painted Snipe | 5 | 5 | |
| Black-winged Stilt | 48 | 300 | 300 |
| Avocet | 1 | 1 | |
| Water Dikkop | 86 | 86 | 25 |
| Spotted Dikkop | 3 | 3 | |
| Common Pratincole | 420 | 2000 | 2000 |
| Ringed Plover | 15 | 15 | |
| Kittlitz's Plover | 200 | 200 | 120 |
| Three-banded Plover | 20 | 20 | 3 |
| White-fronted Sand Plover | 3 | 3 | |
| Senegal Wattled Plover | 6 | 6 | |
| White-crowned Plover | 5 | 5 | |
| Blacksmith Plover | 11 | 11 | |
| Spur-winged Plover | 2 | 4 | 4 |
| Lesser Black-winged Plover | 2 | 2 | |
| Long-toed Plover | 47 | 200 | 200 |
| Ethiopian Snipe | 3 | 3 | 1 |
| Great Snipe | 17 | 17 | |
| Common Redshank | 15 | 15 | |
| Marsh Sandpiper | 26 | 26 | |
| Greenshank | 32 | 32 | 18 |
| Wood Sandpiper | 35 | 35 | 33 |
| Common Sandpiper | 42 | 42 | 18 |
| Little Stint | 300 | 400 | 400 |
| Curlew Sandpiper | 25 | 25 | |
| Ruff | 77 | 77 | |
| Grey-headed Gull | 100 | 100 | 4 |
| Whiskered Tern | 100 | 3000 | 3000 |
| White-winged Tern | 206 | 206 | |
| African Skimmer | 600 | 600 | 28 |
| Pel's Fishing Owl | 0 | 0 | |
| Marsh Owl | 2 | 2 | |
| Malachite Kingfisher | 0 | 28 | 28 |
| Giant Kingfisher | 0 | 2 | 2 |
| Pied Kingfisher | 0 | 300 | 300 |
| African Pied Wagtail | 5 | 5 | |

## 8.4 Description of present-day biota

### 8.4.1 Checklist of the waterbirds of the Elephant Marsh area

The information contained in the sources described above, i.e. published literature and reports, African Waterbird Census and this study, allow the compilation of a comprehensive checklist of the waterbird species recorded in the Elephant Marsh area, i.e. between Chikwawa in the north and Chiromo in the south (Table 40). The information in some of these sources, however, make it difficult to confirm whether a particular waterbird has actually been recorded in the Elephant Marsh itself or in the broader 'lower Shire River' region possibly outside the actual Elephant Marsh. Instances where such doubt exists are identified in the table. Proof of breeding by the relevant waterbird species is also presented in the table.

In all, a total of 110 waterbird species have been recorded at Elephant Marsh (excluding Spotted Redshank). A total of 26 of these species have been found breeding at Elephant Marsh. A further 12 waterbird species have been recorded in the broader lower Shire River area (and likely occur at least occasionally at Elephant Marsh, excluding Striped Crake). A total of eight species have not yet been confirmed breeding at Elephant Marsh but have been found breeding in the broader lower Shire River area (and may therefore breed at Elephant Marsh). This assessment of the number waterbird species at Elephant Marsh is made notwithstanding the apparent anomaly of the members of some waterbird families as defined by the Ramsar Convention being largely or indeed exclusively 'non-aquatic' in their habits, e.g. Abdim's and White storks, Spotted Dikkop, Bronze-winged and Temminck's coursers, Black-winged Pratincole, and Caspian and Lesser Black-winged plovers. Several of these species are also only represented by historical records with no evidence of recent occurrence at Elephant Marsh, e.g. Wattled and Southern Crowned cranes. And, of course, many of these birds would only ever be rare vagrants to the system and indeed Malawi as a whole, e.g. many of the Scolopacidae (sandpipers).

**Table 40. A comprehensive checklist of the waterbird species recorded at the Elephant Marsh (i.e. between Chikwawa in the north and Chiromo in the south) drawn from all the sources examined in this report, i.e. published literature and reports, African Waterbird Census and this study. Also included are waterbird species that have been recorded in the broader 'lower Shire River' area but without definite confirmation that these species have been recorded at Elephant Marsh itself. Species recorded at Elephant Marsh during this study are shown in bold. P = present; B = breeding.**

| Common name | Scientific name | Elephant Marsh | 'lower Shire River' |
|---|---|---|---|
| **Little Grebe** | *Tachybaptus ruficollis* | P | |
| **White-breasted Cormorant** | *Phalacrocorax carbo* | P | B |
| **Reed Cormorant** | *Phalacrocorax africanus* | P | B |
| **African Darter** | *Anhinga rufa* | P | |
| White Pelican | *Pelecanus onocrotalus* | P | |
| **Pink-backed Pelican** | *Pelecanus rufescens* | PB | |
| **Little Bittern** | *Ixobrychus minutus* | P | |
| Dwarf Bittern | *Ixobrychus sturmii* | P | |
| **Black-crowned Night Heron** | *Nycticorax nycticorax* | P | B |
| White-backed Night Heron | *Gorsachius leuconotus* | P | |
| Madagascar Squacco Heron | *Ardeola idae* | P | |
| **Common Squacco Heron** | *Ardeola ralloides* | P | |
| Rufous-bellied Heron | *Ardeola rufiventris* | P | |

| Common name | Scientific name | Elephant Marsh | 'lower Shire River' |
|---|---|---|---|
| **Cattle Egret** | *Bubulcus ibis* | P | |
| **Green-backed Heron** | *Butorides striata* | PB | |
| **Black Egret** | *Egretta ardesiaca* | P | |
| **Little Egret** | *Egretta garzetta* | P | |
| **Yellow-billed Egret** | *Egretta intermedia* | P | |
| **Great White Egret** | *Egretta alba* | P | |
| **Purple Heron** | *Ardea purpurea* | P | |
| **Grey Heron** | *Ardea cinerea* | P | |
| **Black-headed Heron** | *Ardea melanocephala* | PB[1] | |
| **Goliath Heron** | *Ardea goliath* | P | B |
| **Hamerkop** | *Scopus umbretta* | PB | |
| **Yellow-billed Stork** | *Mycteria ibis* | P | |
| **Openbill Stork** | *Anastomus lamelligerus* | PB[2] | |
| Black Stork | *Ciconia nigra* | P | |
| Abdim's Stork | *Ciconia abdimii* | | P |
| Woolly-necked Stork | *Ciconia episcopus* | P | B |
| White Stork | *Ciconia ciconia* | P | |
| Saddle-billed Stork | *Ephippiorhynchus senegalensis* | P | B |
| Marabou Stork | *Leptoptilos crumeniferus* | PB | |
| **Sacred Ibis** | *Threskiornis aethiopicus* | P | |
| **Glossy Ibis** | *Plegadis falcinellus* | P | |
| **Hadeda Ibis** | *Bostrychia hagedash* | P | |
| **African Spoonbill** | *Platalea alba* | P | |
| **Greater Flamingo** | *Phoenicopterus ruber* | P | |
| **Lesser Flamingo** | *Phoeniconaias minor* | | P |
| **Fulvous Tree Duck** | *Dendrocygna bicolor* | PB | |
| **White-faced Tree Duck** | *Dendrocygna viduata* | PB | |
| White-backed Duck | *Thalassornis leuconotus* | PB | |
| **Egyptian Goose** | *Alopochen aegyptiaca* | P | B |
| **Spur-winged Goose** | *Plectropterus gambensis* | P | |
| **Knob-billed Duck** | *Sarkidiornis melanotos* | PB | |
| Pygmy Goose | *Nettapus auritus* | PB | |
| African Black Duck | *Anas sparsa* | | P |
| Yellow-billed Duck | *Anas undulata* | | P |
| **Red-billed Teal** | *Anas erythrorhyncha* | P | |
| **Hottentot Teal** | *Anas hottentota* | PB | |
| Garganey | *Anas querquedula* | | P |
| Southern Pochard | *Anas hottentota* | P | |
| **African Fish Eagle** | *Haliaeetus vocifer* | PB | |
| **Eurasian Marsh Harrier** | *Circus aeruginosus* | P | |
| **African Marsh Harrier** | *Circus ranivorus* | P | |
| **Osprey** | *Pandion haliaetus* | P | |
| African Water Rail | *Rallus caerulescens* | PB | |
| Corncrake | *Crex crex* | P | |
| African Crake | *Crecopsis egregia* | P | |
| **Black Crake** | *Amaurornis flavirostra* | PB | |
| Striped Crake | *Aenigmatolimnas marginalis* | | (P[3]) |

| Common name | Scientific name | Elephant Marsh | 'lower Shire River' |
|---|---|---|---|
| **Purple Gallinule** | *Porphyrio porphyrio* | P | |
| **Lesser Gallinule** | *Porphyrio alleni* | PB | |
| **Common Moorhen** | *Gallinula chloropus* | P | |
| Lesser Moorhen | *Gallinula angulata* | PB | |
| Red-knobbed Coot | *Fulica cristata* | P | |
| Wattled Crane | *Grus carunculatus* | P | |
| Southern Crowned Crane | *Balearica regulorum* | P | |
| African Finfoot | *Podica senegalensis* | P | |
| **African Jacana** | *Actophilornis africanus* | PB | |
| **Lesser Jacana** | *Microparra capensis* | PB | |
| **Painted Snipe** | *Rostratula benghalensis* | PB | |
| **Black-winged Stilt** | *Himantopus himantopus* | P | |
| **Avocet** | *Recurvirostra avosetta* | P | |
| **Water Dikkop** | *Burhinus vermiculatus* | P | |
| Spotted Dikkop | *Burhinus capensis* | P | |
| Bronze-winged Courser | *Rhinoptilus chalcopterus* | | P |
| Temminck's Courser | *Cursorius temminckii* | | P |
| **Common Pratincole** | *Glareola pratincola* | PB | |
| Black-winged Pratincole | *Glareola nordmanni* | | P |
| **Ringed Plover** | *Charadrius hiaticula* | P | |
| **Kittlitz's Plover** | *Charadrius pecuarius* | PB | |
| **Three-banded Plover** | *Charadrius tricollaris* | P | |
| White-fronted Sand Plover | *Charadrius marginatus* | P | |
| Caspian Plover | *Charadrius asiaticus* | P | |
| Pacific Golden Plover | *Pluvialis fulva* | P | |
| Grey Plover | *Pluvialis squatarola* | | P |
| Senegal Wattled Plover | *Vanellus senegallus* | P | |
| White-crowned Plover | *Vanellus albiceps* | P | |
| Blacksmith Plover | *Vanellus armatus* | P | |
| Spur-winged Plover | *Vanellus asspinosus* | P | |
| Lesser Black-winged Plover | *Vanellus lugubris* | P | |
| **Long-toed Plover** | *Vanellus crassirostris* | P | |
| Ethiopian Snipe | *Gallinago nigripennis* | P | |
| Great Snipe | *Gallinago media* | P | |
| **Black-tailed Godwit** | *Limosa limosa* | P | |
| Bar-tailed Godwit | *Limosa lapponica* | P | |
| Whimbrel | *Numenius phaeopus* | | P |
| Common Redshank | *Tringa totatus* | P | |
| Spotted Redshank | *Tringa erythropus* | (P[4]) | |
| **Marsh Sandpiper** | *Tringa stagnatilis* | P | |
| **Greenshank** | *Tringa nebularia* | P | |
| Green Sandpiper | *Tringa ochropus* | P | |
| **Wood Sandpiper** | *Tringa glareola* | P | |
| Terek Sandpiper | *Xenus cinereus* | | P |
| **Common Sandpiper** | *Actitis hypoleucos* | P | |
| Sanderling | *Calidris alba* | P | |
| **Little Stint** | *Calidris minuta* | P | |

| Common name | Scientific name | Elephant Marsh | 'lower Shire River' |
|---|---|---|---|
| **Curlew Sandpiper** | *Calidris ferruginea* | P | |
| **Ruff** | *Philomachus pugnax* | P | |
| Lesser Black-backed Gull | *Larus fuscus* | | P |
| **Grey-headed Gull** | *Larus cirrocephalus* | P | |
| Common Tern | *Sterna hirundo* | P | |
| **Whiskered Tern** | *Chlidonias hybrida* | P | |
| **White-winged Tern** | *Chlidonias leucopterus* | P | |
| **African Skimmer** | *Rynchops flavirostris* | PB | |
| Pel's Fishing Owl | *Scotopelia peli* | PB | |
| Marsh Owl | *Asio capensis* | PB | |
| Half-collared Kingfisher | *Alcedo semitorquata* | P | |
| **Malachite Kingfisher** | *Alcedo cristata* | P | |
| **Giant Kingfisher** | *Megaceryle maxima* | P | |
| **Pied Kingfisher** | *Ceryle rudis* | PB | |
| Yellow Wagtail | *Motacilla flava* | P | |
| Long-tailed Wagtail | *Motacilla clara* | P | |
| **African Pied Wagtail** | *Motacilla aguimp* | P | B |

[1] – A colony of about 10 nests in a baobab tree on the edge of the marsh was seen during one of the microlight flights.
[2] – A small colony of five nests in reedbeds was seen during one of the microlight flights.
[3] – The single record from the lower Shire River region from Nsanje/Ndindi is considered doubtful by Dowsett-Lemaire & Dowsett (2016)
[4] – The single record (of four birds) from Sucoma is rejected by Dowsett-Lemaire & Dowsett (2016)

### 8.4.2 Waterbird population estimates

The various counts of individual waterbird species at Elephant Marsh made during this survey in March 2016 cannot be simply summed to arrive at totals for individual species, and a grand total covering all species, for the marsh as a whole. One reason is that, although 'double-counting' was controlled within wetland count types, there was nevertheless some overlap in the areas counted between the microlight counts and the counts from the land/boat in the extensive lagoon systems in the southern-most parts of the marsh, which could have resulting in some 'double-counting'. Any overlap between the microlight counts and the other counts conducted during this survey, however, are considered likely to be negligible and are ignored here. In order to control for the potential overlap between the microlight and land/boat counts in the lagoon systems, only the highest number of birds counted for each species from one or other of these counts in the overlapping lagoon was extracted and used. Table 41 therefore summarizes all the waterbird count data (excluding that of roosting birds) from this survey with all potential sources of 'double-counting' controlled for as far as possible.

**Table 41. Summary totals of all the waterbird counts made during the March 2016 survey (excluding counts at roosts) with all potential sources of 'double-counting' controlled for, in particular the figures from the microlight flights exclude all data from the lower lagoons that were also counted from land/boat and the figures for the lower lagoons include only the highest figure from either the microlight flights over the lower lagoons or the land/boat counts covering these lagoons.**

| Species | Microlight | Lagoons | Channels | Focus wetland | TOTALS |
|---|---|---|---|---|---|
| White-breasted Cormorant | 8 | 13 | | | **21** |
| Reed Cormorant | 67 | 535 | | 21 | **623** |
| African Darter | 27 | 30 | 3 | | **60** |
| Pink-backed Pelican | 44 | 41 | | | **85** |
| Little Bittern | | 2 | | 3 | **5** |
| Black-crowned Night Heron | 4 | 2 | | 3 | **9** |
| Common Squacco Heron | 1380 | 265 | 6 | 31 | **1682** |
| Cattle Egret | 1651 | 79 | 61 | | **1791** |
| Green-backed Heron | | | 1 | 3 | **4** |
| Black Egret | 1 | 72 | 2 | 14 | **89** |
| Little Egret | 285 | 36 | 5 | 2 | **328** |
| Yellow-billed Egret | 1 | 16 | 1 | | **18** |
| Great White Egret | 169 | 31 | 4 | 2 | **206** |
| Egret spp. | 562 | | | | **562** |
| Purple Heron | 27 | 61 | 2 | 2 | **92** |
| Grey Heron | 32 | 26 | 26 | 3 | **87** |
| Black-headed Heron | 14 | | 7 | | **21** |
| Goliath Heron | 12 | 7 | | | **19** |
| Hamerkop | | 1 | | 2 | **3** |
| Yellow-billed Stork | 98 | 32 | 1 | | **131** |
| Openbill Stork | 1435 | 2526 | 22 | 8 | **3991** |
| Sacred Ibis | 104 | 10 | 1 | | **115** |
| Glossy Ibis | 41 | 13 | 2 | | **56** |
| African Spoonbill | 5 | | | | **5** |
| Greater Flamingo | 148 | | | | **148** |
| Fulvous Tree Duck | 204 | 88 | | | **292** |
| White-faced Tree Duck | 2821 | 245 | 73 | 116 | **3255** |
| Egyptian Goose | 2 | | | | **2** |
| Spur-winged Goose | 105 | 60 | 3 | 2 | **170** |
| Knob-billed Duck | 507 | | | 2 | **509** |
| Red-billed Teal | 169 | | | 2 | **171** |
| Hottentot Teal | 5 | 1 | | | **6** |
| African Fish Eagle | 10 | 14 | 4 | | **28** |
| African Marsh Harrier | | 3 | 3 | 2 | **8** |
| Osprey | | 1 | | | **1** |
| Black Crake | | 14 | | 20 | **34** |
| Purple Gallinule | 4 | 45 | 1 | 6 | **56** |
| Lesser Gallinule | | | | 6 | **6** |
| Common Moorhen | | 3 | | | **3** |
| African Jacana | 53 | 1345 | 7 | 122 | **1527** |
| Lesser Jacana | | 31 | | | **31** |
| Painted Snipe | | 1 | | 1 | **2** |

| Species | Microlight | Lagoons | Channels | Focus wetland | TOTALS |
|---|---|---|---|---|---|
| Black-winged Stilt | 156 | 20 | 1 | 2 | **179** |
| Avocet | 2 | | | | **2** |
| Water Dikkop | | | | 1 | **1** |
| Common Pratincole | 800 | 50 | | | **850** |
| Ringed Plover | | 1 | | | **1** |
| Kittlitz's Plover | | 1 | | | **1** |
| Three-banded Plover | | 2 | | 1 | **3** |
| Long-toed Plover | 23 | 86 | 5 | | **114** |
| Black-tailed Godwit | | 1 | | | **1** |
| Marsh Sandpiper | | 1 | | | **1** |
| Greenshank | 9 | 3 | 1 | 1 | **14** |
| Wood Sandpiper | 21 | 51 | 2 | 22 | **96** |
| Common Sandpiper | | 13 | 2 | 2 | **17** |
| Little Stint | 250 | 467 | | 3 | **720** |
| Curlew Sandpiper | | 200 | | | **200** |
| Ruff | 720 | 14 | 7 | 1 | **742** |
| Palearctic waders | 18 | | | | **18** |
| Grey-headed Gull | | 8 | | | **8** |
| Whiskered Tern | | 245 | | 1 | **246** |
| White-winged Tern | 105 | 431 | 4 | | **540** |
| African Skimmer | 111 | 2 | | | **113** |
| Malachite Kingfisher | | 8 | 2 | 9 | **19** |
| Pied Kingfisher | 3 | 60 | 13 | 24 | **100** |
| **TOTALS** | **12 213** | **7313** | **272** | **440** | **20 238** |

The figures in Table 41, however, are bedevilled by an even more serious problem, however, related to the opposite end of the spectrum from 'double-counting': undercounting related to large parts of the wetland simply not having been covered by any of the counts. It is not easy to compensate for this by simple extrapolation as the respective boundaries of the areas covered and not covered are not easily determined in practice, especially for the data from the microlight flights. In addition, the marsh is heterogeneous in nature, with waterbirds differentially concentrated in some areas. The March 2016 waterbird counts were also not random in nature and were concentrated in areas with particularly high waterbird numbers. A third confounding factor is that even in the areas covered by the counts, different waterbird species would have been counted with different levels of accuracy largely based on their size, colouration, habits and their selection of microhabitats within the marsh. For example, few individuals would likely have been missed in the areas covered of species such as Pink-backed Pelican, Cattle, Little and Great White egrets, Grey and Goliath herons, Openbill and Yellow-billed storks, Sacred Ibis, African Fish Eagle, Grey-headed Gull, Whiskered and White-winged terns, and African Skimmer, while higher proportions would have been overlooked in other species such as Reed Cormorant (especially when swimming), Common Squacco Heron (when not in flight), Purple Heron, Glossy Ibis, Hottentot Teal, Purple Gallinule, African Jacana, Black-winged Stilt and Long-toed Plover. For species that are small and/or skulking in their habits, the number of individuals overlooked in the areas of the marsh purportedly covered could have been very high indeed, e.g. Little Bittern, Black-crowned Night Heron, Black Crake, Lesser Gallinule, Lesser Jacana, Painted Snipe, Wood Sandpiper, Little Stint and Ruff. Clear examples of these differences in conspicuousness are apparent when comparing the waterbird count data from the microlight flights with that from the ground and boat counts, with species found to be common in the latter counts being poorly, or at least relatively poorly, represented in the microlight counts, e.g. Reed Cormorant, Purple Heron, Black Crake, Purple Gallinule, African Jacana, Lesser Jacana and Long-toed Plover (compare the data in Table 32 and Table 36). It might be possible to make some conservative extrapolations to estimate the total population sizes of at least some of the waterbirds counted during the March 2016 survey across the entire marsh and this still being investigated.

It follows from the discussion above that the figures in Table 41 represent undercounts for all or virtually all species , and likely to an appreciable extent, especially for the less conspicuous waterbird species.

The Ramsar Convention considers a wetland to be of 'international importance' if it regularly supports over 20 000 waterbirds. The grand total of all waterbirds counted at Elephant Marsh during the March 2016 survey (Table 41) exceeds this threshold. This applies even with the figures for African Fish Eagle, African Marsh Harrier, Osprey, and Malachite and Pied kingfishers, i.e. species technically not classified as waterbirds by Ramsar, excluded. It should also be noted that the roost counts described in Section 8.3.6 above recorded totals for three species that are higher than those recorded during the waterbird counts covered by Table 41, i.e. Cattle Egret – 3333, Black-crowned Night Heron – 166 and Glossy Ibis – 100. If the grand total is adjusted by removing the figures for the aquatic raptors and kingfishers and substituting the figures for the roosting egrets, herons and ibises, the total rises to 21 825.

A wetland can also be classified as 'a wetland of international importance' under the Ramsar Convention if it regularly supports 1% or more of a delineated population of a waterbird species. Appendix 6F lists the 1% population thresholds for the waterbird species (as defined by the Ramsar Convention) that have been recorded at Elephant Marsh or at least in the lower Shire River area, as taken from Wetlands International (2016).

The March 2016 counts revealed totals in excess of the 1% thresholds for the following species (Table 41): Openbill Stork (counted - 3991, 1% threshold – 3900; Figure 54), Whiskered Tern (counted – 246, 1% threshold – 85), and African Skimmer (counted 113, 1% threshold – 100). The African Waterbird Census counts (Table 39, Appendices 6D&E) have also reported numbers of Whiskered Terns in excess of the 1% threshold, i.e. 100 in July 2012 and 3000 in January 2016 (although the latter figure calls for confirmation). The AWC counts have also regularly recorded African Skimmers in numbers in excess of the 1% threshold, i.e. 332 in August 2008, 283 in July 2011, 300 in March 2012, 360 in September 2012, and 600 in January 2016 (with the last figure again possibly requiring confirmation). In addition, the AWC count of January 2016 recorded 2000 Common Pratincoles (1% threshold – 1000) and the March 2016 survey counted 850 individuals of this species.

Given that the March 2016 survey and the AWC counts are undercounts to at least some degree for all, or virtually all, species, it also seems likely that the actual numbers of the following species in Elephant Marsh also exceed the 1% Ramsar thresholds on the basis of the numbers that have been counted by one or both efforts counted: Common Squacco Heron (counted March 2016 – 1682, 1%

threshold – 4200; Figure 55), Black Egret (counted January 2016 – 800, 1% threshold – 1000), and Long-toed Plover (counted January 2016 – 200 and March 2016 – 114, 1% threshold – 350).

**Figure 54. An Openbill Stork photographed at Elephant Marsh during this survey.**

**Figure 55. Common Squacco Heron at Elephant Marsh.**

It would also not be surprising should the actual populations of the following retiring species, for which Elephant Marsh offers abundant habitat, exceed the relevant 1% thresholds: Little Bittern, Purple Heron, Black Crake, Lesser Gallinule, Painted Snipe and Water Dikkop.

In conclusion, there is thus clear evidence that Elephant Marsh qualifies as a 'wetland of international' importance based on its waterbird populations both relative to the total number of waterbirds present (>20 000) and relative to certain waterbird species exceeding the relevant 1% population thresholds.

### 8.4.3 Waterbird species of formal conservation concern

Eight of the waterbird species that have been recorded at Elephant Marsh or at least in the lower Shire River area (Table 40) are formally considered globally threatened (see: http://www.birdlife.org/datazone/country/malawi). These are: Madagascar Squacco Heron, Lesser Flamingo, Wattled Crane, Southern Crowned Crane, Great Snipe, Bar-tailed Godwit, Curlew Sandpiper and African Skimmer. However, and as detailed below, for only one of these species, African Skimmer, does the Elephant Marsh appear to be a significant locality. Otherwise, the value of Elephant Marsh lies in its supporting a wide diversity of waterbirds and, more especially, particularly high numbers of aquatic birds.

#### *8.4.3.1 Madagascar Squacco Heron*

The Madagascar Squacco Heron, globally classified as 'Endangered', is a rare non-breeding visitor to Malawi during the winter months (April – November). It is difficult to differentiate in the field from the Common Squacco Heron. Dowsett-Lemaire (2006) lists about 20 records for Malawi, one of which comes from Elephant Marsh (one photographed 18 April 2002).

#### *8.4.3.2 Lesser Flamingo*

The Lesser Flamingo, globally classified as 'Near-threatened', is an irregular visitor to Malawi (Dowsett-Lemaire & Dowsett 2006). The species has been recorded in the lower Shire River area but no records specific to Elephant Marsh could be traced (Table 40). As with its status in Malawi generally, it would be at best an irregular visitor to the marsh.

#### *8.4.3.3 Wattled Crane*

There are some four historical records of Wattled Crane, globally classified as 'Vulnerable', from the lower Shire River area, including two from Elephant Marsh (Long 1960, 1967, Dowsett-Lemaire 2006, Dowsett-Lemaire & Dowsett 2006). The most recent record is of a pair in Elephant Marsh in October 1972. The broader Zambezi drainage region is the global stronghold of the Wattled Crane, with major populations at sites such as the Kafue Flats in Zambia and the Zambezi floodplain in Mozambique (Timberlake 2000a). The historical record of this species at Elephant Marsh too meagre to allow any determination of its past status at this locality. It could conceivably have occurred and bred at Elephant Marsh in its pristine state in reasonable numbers or may always have been just a rare visitor. The Wattled Crane is known to be particularly sensitive to disturbance, especially when breeding.

#### 8.4.3.4 Southern Crowned Crane

The status of the Southern Crowned Crane, globally classified as 'Endangered', in the lower Shire River area is somewhat similar to that of the Wattled Crane. There are a few historical records, including from Elephant Marsh itself (e.g. Long 1967), but no recent records (Dowsett-Lemaire & Dowsett 2006). Dowsett-Lemaire & Dowsett (2006) attribute its disappearance from the lower Shire River area to "habitat alteration and disturbance".

#### 8.4.3.5 Great Snipe

The Great Snipe, globally classified as 'Near-threatened', is an uncommon non-breeding Palearctic migrant to Malawi. It is difficult to differentiate in the field from the Ethiopian Snipe, which confounds determining its true status in the region. Two specimens were shot at Elephant Marsh in December 1917 (Belcher 1930). Hanmer (1998) mentions two individuals of this species examined in the hand at Elephant Marsh sometime in the 16 years 1973-1989. The African Waterbird Count at Elephant Marsh in February 2014 counted 17 individuals of this species (but no Ethiopian Snipe and without further details this record should perhaps be treated with caution). The current status of this skulking species at Elephant Marsh is unclear and worthy of further investigation, taking care to diligently differentiate this species from Ethiopian Snipe.

#### 8.4.3.6 Bar-tailed Godwit

The Bar-tailed Godwit, globally classified as 'Near-threatened', is a rare non-breeding Palearctic passage vagrant to Elephant Marsh and Malawi generally (Dowsett-Lemaire 2006, Dowsett-Lemaire & Dowsett 2006).

#### 8.4.3.7 Curlew Sandpiper

The Curlew Sandpiper, globally classified as 'Near-threatened', is a relatively common non-breeding Palearctic migrant to Elephant Marsh and Malawi generally. The 25 African Waterbird Counts at Elephant Marsh recorded the species on three counts, with a total of 25 being the highest number of individuals counted on any one count (Table 40 and Appendices 6D&E). A flock of some 200 individuals was recorded on an open sandbank in an expansive lagoon in the southern parts of the marsh during this survey on 14 March 2016 (Table 36 and Appendix 6C).

#### *8.4.3.8 African Skimmer*

The African Skimmer, globally classified as 'Near-threatened', has long been known to be particularly common at Elephant Marsh (e.g. Percival 1902). The Shire River is the stronghold for the species in Malawi (Dowsett-Lemaire & Dowsett 2006).

It was first found breeding at Elephant Marsh in October 1981 and this also represented the first breeding records for Malawi (Hanmer 1982b). The total population in the Elephant Marsh area at that time was estimated as in excess of 200 individuals by Hanmer (1982b).

The species is believed most common along the Shire River in this area during the period May to January, e.g. "large flocks are normally recorded from Aug. to Nov. or Dec.: as in Aug.-Sep. at Nchalo from 1973-76, Aug.-Nov. 1977 upriver from Sucoma", "c. 200 (with many immatures) at Chiromo on 9 Nov. 1981", "large flocks" May-July 1984, a large flock January 1985 followed by "only small numbers until May when the species was numerous again", "c. 200 near the Mwanza confluence Aug.-Oct. 1986", "100+ in the Elephant Marsh Aug. 1987", and "In the Shire numbers build up Jul-Aug, and in some years earlier (May), and the species remains numerous until at least Nov; flocks often number 200-300 birds in Aug-Nov at various points along the river (from 1534D4 to 1635C1)" (Hanmer 1982b, 1989b, 1989c, Dowsett-Lemaire 2006, Dowsett-Lemaire & Dowsett 2006). May-January would correspond with the period when water levels along the Shire river would be at their lowest, exposing the sandbanks.

The 25 African Waterbird Counts at Elephant Marsh recorded the species on eight counts (Table 39 and Appendix 6). The highest number of birds counted was 600 in January 2015 (a number more suggestive of an estimate rather than an actual count) and the next highest counts were of 360 in September 2012, 332 August 2008, 300 in March 2012 and 283 July 2011.

During this survey, conducted when water levels in the Shite River were seasonally high (i.e. conditions of low favourability for the bird), at total of 114 individuals of this species were recorded on four separate occasions (Table 32 and Table 36, Appendices 6B&C and Figure 56):

- A flock of 43 birds found in the main channel of the upper Shire River on 9 March 2016 during one of the microlight flights;
- A flock of 68 birds also located in the main channel of the upper Shire River on the same date and on the same flight;
- A single bird recorded in a main channel of the lower Shire River on 10 March also during one of the microlight flights; and
- Two birds recorded on the edge of the western-most lagoon in the southern part of Elephant Marsh on 9 March.

The total global population size of the African Skimmer is estimated at 15 000-25 000 birds, with 8 000-12 000 of these present in eastern and southern Africa. The population of the upper and middle Zambezi River system (from the source of the Zambezi in Zambia to its confluence with the Luangwa River on the Mozambique border) has been estimated at 1428 individuals (Coppinger et al. 1988).

The species is threatened in the Elephant Marsh area by disturbance when breeding from fishermen and upstream regulation of water supply related to hydro-electric schemes (Hanmer 1977, Dowsett-Lemaire & Dowsett 2006).

**Figure 56. A flock of African Skimmers flying over the main channel of the Shire river in Elephant Marsh photographed during the microlight surveys.**

### 8.4.4 Colonially breeding waterbirds of significance

An initial aim of this survey was to search for any large communal breeding colonies of waterbirds in Elephant Marsh. The microlight flights were particularly well suited for locating such sites. No such large colonies were located, although small single colonies of breeding Openbill Storks and Black-headed Herons were found (see below and Table 40). It is unlikely that any such large congregations of colonially nesting waterbirds in the marsh would have been overlooked during these flights.

This survey was made when water levels were still rising in the marsh and colonially breeding waterbirds tend to breed when water levels are falling. It is thus possible that colonial waterbirds might be found breeding in numbers at other times of the year at Elephant Marsh (or perhaps in years with higher water levels – this survey was made during a markedly dry season). Alternatively, such waterbirds may prefer traditional breeding sites situated elsewhere in the broader region. It is also possible that high levels of disturbance by humans in the marsh precludes the establishment of large, colonial breeding sites, especially as such breeding sites would have to be situated in relatively accessible reedbeds due to the destruction of most of the large trees in the marsh and immediately surrounding areas – such waterbirds also typically prefer nesting in inundated trees which renders those in the areas surrounding the marsh less attractive.

#### 8.4.4.1 Pink-backed Pelican

Breeding by Pink-backed Pelicans in the Nsanje area south of Elephant Marsh has been known since 1924, when about 100 birds nested in tall trees (Belcher 1928, Long 1956, 1960, Dowsett-Lemaire & Dowsett 2006). Up to 140 pairs nested in tall trees at several different localities in the Nsanje area during the period 1952-1956, with active breeding being initiated in January-February. Subsequently, two additional breeding colonies became established in the area in the period 1957-1962, one at Chiromo on the edge of Elephant Marsh (Long 1967). An unconfirmed nesting attempt by the species in the Sucoma Fish Ponds from August 1982 was reported by Dale Hanmer and a "few nests", one with a nestling, were recorded in baobabs at James's Landing in April 2002 – both localities on the edge of Elephant Marsh (Dowsett-Lemaire 2006, Dowsett-Lemaire & Dowsett 2006). The trees used by the birds that previously nested in the Nsanje area were apparently felled by Renamo rebels in 1990 (Dowsett-Lemaire 2006, Dowsett-Lemaire & Dowsett 2006). The lower Shire River area is the only region in Malawi where this species has been recorded breeding (Dowsett-Lemaire & Dowsett 2006).

Although this survey occurred during the normal breeding period of this species and this pelican was counted in fairly high numbers on the marsh, no breeding was found in the area covered during this survey. Determining the current breeding status of this species in the lower Shire River area should be considered a priority.

**Figure 57. Pink-backed Pelican at Elephant Marsh.**

#### 8.4.4.2 Marabou Stork

Like the Pink-backed Pelican, Marabou Storks also have a long tradition of breeding in the lower Shire River area (Belcher 1930, Benson & Benson 1947, Long 1956, 1960). Up to 67 pairs of Marabou Storks nested in tall trees at several different localities in the Nsanje area during the period 1951-1955. Long (1956) also mentioned that Marabou Storks were also known to breed at Ngabu, on the edge of Elephant Marsh, "and elsewhere in Chikwawa District" during that period. Eight were reported nesting at Ngabu in July 1997 (Dowsett-Lemaire 2006), although it is unclear if this refers to the number of birds or the number of breeding pairs. Dowsett-Lemaire & Dowsett (2006) report Marabou Storks to have bred at both Ngabu and Sorgin in 1998.

As with the Pink-backed Pelican, most of the trees used by the birds that previously nested in the Nsanje area were apparently felled by Renamo rebels in 1990 (Dowsett-Lemaire 2006, Dowsett-Lemaire & Dowsett 2006). The lower Shire River area is the stronghold of the species in Malawi and virtually all breeding has been recorded from this region (Dowsett-Lemaire & Dowsett 2006). The species is believed to have decreased at Elephant Marsh and in the lower Shire River area generally since at least the 1950's, related to the loss of nesting trees and possibly human disturbance (Dowsett-Lemaire & Dowsett 2006).

The species appears to be largely a winter migrant to the region, arriving in June-July to nest, with most departing after the breeding season (Long 1956, 1967). This would explain why the species was not recorded in the area during this survey. As with the Pink-backed Pelican, determining the current breeding status of this species in the lower Shire River area should be considered a priority.

#### *8.4.4.3 Openbill Stork*

A small colony of about five Openbill Stork nests was found in a dense reedbed in the centre of the marsh during the microlight surveys (Table 40, Figure 58). This species has previously been recorded breeding in the lower Shire River area, with up to 30 nests located in the Nsanje area (formerly Port Herald) south of Elephant Marsh during the period 1952-1956, with egglaying occurring January-February (Long 1956, 1960).

**Figure 58. An adult Openbill Stork (centre of the photo) at Elephant Marsh standing on its nest in a reedbed with two well-grown nestlings in front of it.**

## 8.5 Present status of avifauna

In its reference state, Elephant Marsh would still have had natural marsh in the extensive areas currently under cultivation. The reference state would also have supported far more tree cover in the marsh itself and the entire area surrounding the marsh would have comprised tall woodland. The large commercial sugar-cane estates on the edge of the marsh would also have been absent. There would similarly have been no impact on water quantity, quality and flow regulation from the upstream anthropogenic developments that exist in the catchment today. Particularly important would have been the absence of human fishing activities and human disturbance factors. Alien aquatic plant species would have been absent from the system. The frequency of fires during dry periods in the marsh and surrounding areas would have been reduced. The marsh would also have originally supported a mammalian megafauna of species such as elephant, hippo and buffalo, now entirely or largely extirpated.

There is some reflection in the avifaunal literature covering Elephant Marsh of certain of these changes. Percival (1902) mentioned when travelling north of Chiromo on the Shire River to 'Katunga's' by steamboat that there were "trees overhanging the river". Relevant to the shortage of large trees available for large waterbirds to nest in, Long (1956) commented, that "in these days when "many forests and trees have been hewn down, the areas with large trees therefore are at a minimum". He pointed out that "large burial plots, serve to provide refuges for stands of such trees in the region". He specifically noted Pink-backed Pelican and Marabou Storks as having been displaced from breeding sites by such tree felling.

Hanmer (1977) states that "Much of the tree vegetation on the valley floor has gone", with the timber having being used for making planks, building houses, as fuel (including charcoal), to make commercial tobacco cases and to clear land for cultivating maize. She specifically comments on the disturbing destruction of riverine forest in particular and mentions Pel's Fishing Owl and Hamerhop as waterbird species particularly vulnerable in this regard. Hanmer also points out the negative affects on bird populations stemming from an increase in grazing, browsing and trampling pressure from cattle and goats in the valley (as well as frequent burning), which retards the capacity of cleared woody vegetation to regenerate and reduces other ground cover, specifically grasses.

Dowsett-Lemaire & Dowsett (2006) emphasised that tree-felling and human disturbance continue as current negative impacts on breeding Pink-backed Pelicans and Marabou Storks in this region, and note that there is evidence for a decrease in the latter species at Elephant Marsh. Long (1960) also suggested that the Black-crowned Night Heron had become markedly less common after about 1924 and related this to "depletion of woodland in the swamp" and Dowsett-Lemaire & Dowsett (2006) also pointed out the apparent reliance of the species on burial plots and natural thickets in this area, with the latter now "almost all destroyed". Long (1960) also noted that the African Finfoot at Chiromo "possibly no longer occurs as habitat almost wiped out". Dowsett-Lemaire (2006) when discussing a record of White-backed Night Heron "presumably" from Chiromo noted that in this area "there is very little riparian forest left now". Relevant to the Green-backed Heron, Dowsett-Lemaire & Dowsett (2006) reported that this species bred historically on the Ruo and Mwanza rivers where these feed into Elephant Marsh but that "suitable riparian forest disappeared long ago". The African Finfoot and White-backed Night and Green-backed herons all characteristically inhabit watercourses with dense overhanging riparian forest. The Hamerkop and Hadeda Ibis, and even African Pygmy

Goose are three other tree-nesting waterbirds likely to have been prejudiced to at least some extent by extensive tree-felling, including in the Elephant Marsh area (Dowsett-Lemaire & Dowsett 2006). It has been claimed that the Southern Crowned Crane has disappeared from the lower Shire River area due to habitat alteration and disturbance (Dowsett-Lemaire & Dowsett 2006), and it is possible that the Wattled Crane has suffered the same fate in this area – but evidence to substantiate such claims relevant to these two crane species is lacking or at least meagre.

Long (1960) also commented on the high human population of the region and the resultant increased frequency of fires, even into the marsh areas, and erosion related to “poor farming methods” and high stocking rates. Hanmer (1977) mentions the use of fire to assist in clearing marsh areas for cultivation. Dowsett-Lemaire & Dowsett (2006) suggested that the spread of water hyacinth was a potential threat to White-backed Duck and African Pygmy Goose in the Shire River system.

Balancing this though, the early descriptions of the waterbirds of the lower Shire River area in the historical literature hinted at an aquatic avifauna overall very similar to that found today. For example, Long (1956) says of the Openbill Stork that it was “the most abundant species of stork” in this region and Long (1960) said of the African Jacana that it was “Abundant . . . Over 1,000 seen once in Elephant Marsh”.

In conclusion, the current percentage similarity of the waterbird avifauna of Elephant Marsh to its reference condition can be considered in the region of 61-90%, i.e. somewhere between B and C class.  A small number of species have disappeared from the system or at least have been greatly reduced in numbers. A larger portion of species have likely undergone some level of lesser decrease and an equally large portion has likely not decreased at all.

# 9 MAMMALS

## 9.1 Introduction

Early-Malawi had been described as a biodiversity rich area. This was also true for mammals (estimated to have, historically, more than 200 species), and specifically the Elephant Marsh (>140 species) (see section 9.3 where a list of species expected in Malawi and the Elephant Marsh area during those early days are compared with what we find today).

Mammal numbers are expected to have dropped systematically with the increase of humans in the Elephant Marsh area, with highest diversity most probably remaining in pockets further away from the larger human settlements. Human populations have increased over 40% increase within Chikwawa and Nsanje Districts in past 20 years (National Statistics Office, Malawi) and since the start of large scale sugar cane farming, mammal biodiversity most probably decreased further, with only remnants of historical mammal diversity conserved mostly in formally protected areas. Within the study area today mammals are protected in the *c.* 4 000 ha Nyala Park, Nchalo (in the north), and in the 7000 ha Nyasa Wildlife Sanctuary, Kaombe (in the south); both these conservation areas are managed by the sugar cane industry (current species lists given in Table 45 and Table 46). These areas are 45 km apart, and isolated through sugar cane plantations, communal lands, roads and water channels, from each other and from three larger nature reserves outside the study area (Lengwe National Park and Majete Wildlife Reserve, *c.* 10 km WSW and 30 km NW of Nyala Park respectively, and Mwabvi Wildlife Reserve *c.* 10 km WSW of Nyasa Wildlife Sanctuary). On the eastern side of the Shire River the Michuru Mountain Conservation Area is *c*. 15 km NE if Nyala Park, and the Mulanje Mountain Forest Reserve *c.* 70 km ENE of Nyala Park / 80 km NW of the Nyasa Wildlife Sanctuary.

The Nyasa Wildlife Sanctuary, Nyala Park and Majete Wildlife Reserve are Bonex fenced (≈ antelope friendly fencing that allows the larger antelope to move in & out freely as they are well able to jump & clear the fence height). At the Nyasa Wildlife Sanctuary and Nyala Park hippopotamus is unfortunately still fenced out and the individuals outside these conservation areas cannot get in (and *vice versa*; this issue is something that receives attention at the Nyasa Wildlife Sanctuary at moment - Stewart Michael, General Manager, Agricane pers. comm.); at Majete the river frontage falls within the Park. Lengwe National Park is Bonex fenced for approximately 10 kms on either side from the park entrance, otherwise the borders are porous and poaching and illegal tree felling a problem. The Mwabvi Wildlife Reserve is not fenced, and heavy poaching and illegal tree felling is considered to have had a major impact on the ecosystem. The Michuru Mountain Conservation Area falls within the Blantyre City area and is also not fenced; illegal tree felling and heavy poaching saw that very few animals remained. The Mulanje Mountain Forest Reserve is also not fenced and major illegal tree felling (of the Mountain Cedar tree) and poaching is taking place; an active conservation team operating in this area is trying to arrest the situation. Poaching and hunting/trapping/killing is a major issue around these conservation areas, and virtually everything that may be a possible meal is removed (Stewart Michael; Jones Mwabekomo, Wildlife Officer, Nyala Park; Ellard Kombon, wildlife official, Nyala Park; Robert Nyirenda, CFC Nyasa Park wildlife guide; Kondwani, boat driver; unknown security guard at Illovo Sports Club, Nchalo). The result is that little mammal life is currently expected to move between the conservation areas in and around the Elephant Marsh, while ecosystems within the parks are also impacted through illegal poaching and tree felling.

Prior to the field surveys, literature searches were conducted, both stretching from the times when the area was relatively undisturbed until the most recent times when the system was already under the stresses as experienced today. In every case, the species sampled were compared against what was expected to occur, and the species present, as well as the species not found, were used to determine the current condition of the specific habit /ecosystem sampled. To compile a species list of the mammals of Malawi as well as of the Elephant Marsh, historical as well as presently, the following literature were used: Ansell & Dowsett (1988); Skinner & Chimimba (2005); Kingdon *et al.* (2013); Monadjem *et al.* (2010, 2015); Stuart & Stuart 2015; IUCN 2015. These works were based upon distribution records of large numbers of museum's records, research publications, actual observations (historic and present), and habitat preferences compared to habitats present (or sampled) in the study area. The latest taxonomic names and classifications were used, and the species list(s) in Appendix 7A are therefore the most up to date for Malawi and the Elephant Marsh area.

## 9.2 Survey methods

The study area was visited from 7 to 13 March 2016. Within this period is was possible to search for field records from c. 17h30 on 7 March until c. 23h00 on 12 March. Although shorter than one would have hoped for, this period was long enough to get a good idea of the system, its extent, threats and possibilities to recover to its most natural state possible. The field study made use of the five sampling methods indicated below. The data accrued after following these methods were not only used to add to the total sample, but also to verify that species were not misidentified (e.g. as mentioned in species lists or as indicated by the local people). Due to time constraints careful planning of where which kind of method should be applied was based on (1) personal experience (e.g. which species can be expected in which habitats), (2) the diversity of habitats available, (3) the connectivity of habitats to the river, marsh, flooded area, conservation areas within the Elephant Marsh study area, and heavily impacted agricultural areas, (4) how the specific area or habitat is connected with other conservation areas in southern Malawi, (5) which areas are sampled by other team members (e.g. the botanist, ornithologist or herpetologist), and (6) what is logistically possible (e.g. which areas are accessible and or can be reached consistently at specific times – some of them repetitively on a two times-a-day basis).

### 9.2.1 Trapping

Trapping for small mammals (≈ rodents and shrews) community variables such as species richness, diversity, evenness, the presence or absence of indicator species, and the relative contribution of indicator species are regarded as excellent indicators of habitat integrity (see Avenant 2011 for a number of publications on work done in a number of ecosystems in Southern Africa that confirms this statement).

**Table 42. GPS co-ordinates for areas sampled for mammals using carious sampling methods.**

| Type of Sampling | Area description | Latitude (S) | Longitude (E) |
|---|---|---|---|
| Small mammal trapping | Trapline 1 (from/to) | 16°10'08.82" | 34°52'15.05" |
| | | 16°10'09.65" | 34°52'09.53" |
| | Trapline 2 (from/to) | 16°10'07.80" | 34°52'05.82" |
| | | 16°10'08.87" | 34°52'00.30" |
| | Trapline 3 (from/to) | 16°10'16.26" | 34°51'41.46" |
| | | 16°10'16.50" | 34°51'40.92" |
| | Trapline 4 (from/to) | 16°10'59.40" | 34°51'31.98" |
| | | 16°11'04.07" | 34°51'34.86" |
| Bat trapping | Illovo Sports club | 16°16'30.72" | 34°55'08.52" |
| | Nyala Park | 16°16'30.66" | 34°55'06.77" |
| | Nyala Park | 16°10'54.24" | 34°51'26.10" |
| | Mr Sinus Modah's House, adjacent Nyala Park | 16°10'53.28" | 34°51'24.24" |
| Bat detector | Illovo Sports club | 16°16'28.32" | 34°55'07.13" |
| | | 16°16'29.75" | 34°55'06.83" |
| | Nyala Park | 16°10'52.56" | 34°51'29.22" |
| | | 16°10'53.28" | 34°51'24.24" |
| | Kaombe boat launch area | 16°31'54.35" | 35°04'25.08" |
| Mammal signs | Illovo Sports club | 16°16'40.20" | 34°55'08.99" |
| | 500 m along the Shire River north of the Illovo Sports Club | 16°16'11.16" | 34°55'13.79" |
| | Walking inside the Nyala Park | 16°10'24.00" | 34°51'42.00" |
| | Walking on the sides and inside sugar cane plantations | 16°12'52.80" | 34°52'25.20" |
| | Walking around the Kaombe launching pad | 16°31'54.35" | 35°04'25.08" |
| | Walking and driving in the Nyasa Wildlife Sanctuary, Kaombe | 16°33'49.20" | 35°05'15.24" |
| | Searching on islands inside the Shire River complex | 16°10'54.42" | 34°51'26.28" |
| | Searching on islands inside the Shire River complex | 16°24'11.09" | 35°03'07.61" |
| | Banks of the Shire River (from/to) | 16°15'57.42" | 34°55'09.59" |
| | | 16°24'01.31" | 35°02'39.96" |
| | Searching the Bangula Lagoon area near Kaombe (area in between) | 16°31'32.46" | 35°05'37.92" |
| | | 16°31'13.74" | 35°05'25.32" |
| | | 16°31'29.93" | 35°05'58.92" |
| | | 16°31'53.88" | 35°06'30.42" |
| | | 16°31'35.33" | 16°31'35.33" |
| Camera Traps | Camera Trap 1 | 16°10'07.50" | 34°52'03.06" |
| | Camera Trap 2 | 16°10'13.68" | 34°52'00.66" |
| | Camera Trap 3 | 16°10'28.86" | 34°51'34.86" |
| | Camera Trap 4 | 16°10'13.92" | 34°51'42.06" |
| Informal interviews | Two sugar cane workers, Illovo | 16°12'53.52" | 34°52'26.46" |
| | Wildlife Officer Jones Mwabekomo at Nyala Park | 16°10'54.42" | 34°51'26.28" |
| | Wildlife official Ellard Kombon at Nyala Park | 16°10'54.42" | 34°51'26.28" |
| | Inhabitants on a temporary island | 16°22'12.00" | 34°02'24.00" |
| | Stewart Michael (General Manager, Agricane), Kaombe | 16°33'13.01" | 35°04'08.57" |
| | Robert Nyirenda (Guide) Nyasa Wildlife Sanctuary, Kaombe | 16°33'49.20" | 35°05'15.24" |

Because such a survey can be done relatively fast, and the interpretation of results are considered applicable in virtually all African ecosystems, such small mammal monitoring are considered a most convenient way to also indicate positive and negative succession over a long or medium term (over decades, years and months; e.g. when co-occurring herbivore or carnivore species are gradually lost or their community composition change due to e.g. drought, overgrazing, introduction of exotics / invasive species, overexploitation), but also short term (as species generally leave unfavourable habitats within hours in the case of “disasters”, which may be unnatural (such as burns, ploughing, damming areas, shooting missiles) or natural (such as fire and flooding). In the present study it was possible to put out four transects with 35 museum snap traps on each. According to standard trapping method, traps were spaced 5 m (Ferreira & Avenant 2003; Avenant 2011), for a total transect length of 170 m and covering a trap area of 3 800 $m^2$ effectively in each of the four habitats (see a description of the four habitats below). Traps were checked and rebaited when necessary every morning and late afternoon/evening using the standard bait consisting of rolled oats, peanut butter, marmite and sunflower oil (see Avenant 2011 for this motivation).

The four habitats sampled were all in the Nyala Park conservation area or in the surrounding sugar cane just outside the Park (Table 42):

1. Dense, long grass at edge of floodplain
2. Open/closed woodland, undergrowth varying from dense to sparse grass;
3. Dense grass and undergrowth area around a natural pool; and
4. Sugar cane, closest trap < 100 m outside the Park fence).

The traps in habitats 1 to 3 were left open for a continuous period of *c*. 92 hours (= roughly 4 nights and days), and those in habitat 4 for *c*. 70 hours (roughly 3 nights and days). The trap period did not coincide with the 6-day period around full moon, the climate was considered normal for the time of year, and no rain were experienced during the field trip.

### 9.2.2 Bat surveys

Bats were sampled with an AustBat harptrap at four sites: Illovo Sports Club (Nchalo) around the living quarters; Nchalo Sports Club under the trees; at Nyala Park; and at Mr Sinus Modah’s house adjacent to the Nyala Park.

Bats were also sampled indirectly around three general areas with a Pettersson D980 Time expansion bat detector, sounds described using BatSound Pro 3.20 computer software (Petterson Elektronik, Uppsala, Sweden), and identified using the detailed publication of Monadjem *et al.* (2010). The three areas sampled were (1) around the Illovo Sports Club (sampling on and off for *c*. 5 hours); (2) at Nyala Park (sampling for *c*. 3 hours); and (3) at the Kaombe boat launch area (sampling for *c.* 1 hour) (Table 42).

### 9.2.3 Mammal signs

Searching for mammals and mammal signs (e.g. their spoor and scats): walking along the Shire River bank and golf course at the Illovo Sports Club, Nchalo; *c*. 500 m along the Shire River north of the Illovo Sports Club; walking inside the Nyala Park (*c*. 10 hours in total, covering >20 km); walking on the sides and inside sugar cane plantations; walking around the Kaombe launching pad (walking and driving in the Nyasa Wildlife Sanctuary, Kaombe; and searching on islands inside the Shire River complex. In addition, banks of the Shire River and the wetland/flooded area near Kaombe were scanned from boat for any spoor, scats, latrines, runs and slides. See Table 42 for GPS locations.

Hippopotami *Hippopotamus amphibious* were searched for when on the river or flooded area banks, from the boat when on the Shire River and on the flooded area at Kaombe, and from the air (data supplied by Dr David Allan following his two microlight flights over the study area, approximately 5.5 hrs flight time, see Section 8 for details on flight path).

### 9.2.4 Camera traps

Camera traps were used at four localities to get proof of mammals present in the Nyala Park (Table 42):

- Camera 1 – closed woodland (set for *c*. 72 hours);
- Camera 2 – footpath in forest close to small pond (*c*. 72 hours);
- Camera 3 – footpath in dense forest (*c*. 36 hours);
- Camera 4 – at a small, muddy pond in an opening in the forest (*c*. 36 hours).

Trap success were calculated as the number of pictures or videos with mammals captured, divided by the number of hours for which the traps were set. Traps were set sensitive and in such a way that all mammals on the ground, including the relatively small mice, shrews and sengis, would be captured.

### 9.2.5 Informal interviews

Questioning local people about the presence of mammals (making use of the pictures in Stuart & Stuart's 2015 "Field Guide to the Mammals of Southern Africa", co-ordinates in Table 42): two security guards at the Illovo Sports Club, Nchalo (asked independently), two sugar cane workers; Wildlife Officer Jones Mwabekomo at Nyala Park; wildlife official Ellard Kombon at Nyala Park; inhabitants on a temporary island; Stewart Michael (General Manager, Agricane), Kaombe; CFC Nyasa Park wildlife guide Robert Nyirenda at the Nyasa Wildlife Sanctuary. The correctness of the information supplied was duly tested against knowledge of a specific species' habitat preferences, its activity patterns, and its expected presence in the study area. Further information on the mammals in the Kaombe area, in southern Malawi in general, and a species list of the mammals in the Nyasa Wildlife Sanctuary was kindly supplied by Stewart Michael.

## 9.3 Survey results

### 9.3.1 Species historically present/expected in Malawi and at the Elephant Marsh

The mammal species that most probably occurred in Malawi and in and around the Elephant Marsh during recent historical times (late 1800s) are listed in Appendix 7A. Two hundred and five (205) mammal species most probably occurred in Malawi in the late 1800s, and a further 6 should not be totally excluded. This is *c.* 20+ species more than the 187 documented by Ansell & Dowsett (1988) – partly due to additional collections and better sampling and modelling techniques, but also because of a number of taxon-splits relatively recently, motivated by applying the latest genetic analyses. 35% of the historically present and or expected species of Malawi consisted of bats (the largest order), and 26% of rodents (second largest); all carnivores plus all herbivores, together, only contributed 27% to the total number of mammal species.

At the Elephant Marsh 141 mammal species are estimated to have been present during early historical times, and a further 27 could also be present. The 141 species alone is a high 68% of the total mammal fauna estimated for the whole of Malawi. Bats are estimated to have contributed 29%, rodents 23% and carnivores & herbivores 34% to the total number of mammal species at the Elephant Marsh.

A total of 52 species were confirmed as occurring in the Elephant Marsh during this survey.

### 9.3.2 Small mammals (rodents and shrews) sampled during the current study

A fairly large number of rodent and shrew species could be present in the three habitats sampled in the conservation area (= Nyala Park), a subsample of which were expected to be present in high densities (trap success of 10-30% was expected; Table 43).

Fewer species (mainly opportunistic generalists), and in lower numbers, were expected inside the sugar cane plantation (Table 43). More species, like *Steatomys* spp., *Acomys spinosissimus* and *Micaelomys namaquensis* could be present in the general study area but were not expected in the specific habitats/transects sampled (see Table 43). More than 8 species could be present in the long grassland area at the edge of the floodplain, more than 12 species in the open forest, and 5 species in the dense vegetation around the pool. A maximum of two species could possibly be present in the anthropogenically disturbed sugar cane habitat.

Only one species, the opportunist and generalist Natal multimammate mouse *Mastomys coucha*, was found, and then only on Transects 1 and 4 (Table 43). Trap success was also low on these transects (2.9% and 1.9%, respectively). Trap success was 0% on Transects 2 and 3.

### 9.3.3 Bats

Three bat species were caught in the harp traps, these being the Mauritian tomb bat *Taphozous mauritianus*, the Little free-tailed bat *Chaerephon pumilus* and the Angola free-tailed bat *Mops condylurus*. The Yellow-winged bat *Lavia frons* was identified when flying around at the Illovo Sports Club in the late afternoon (at 17h20). Nine bat species could be identified from echolocation recordings (Table 44).

**Table 43. Small mammal species expected versus caught on four transects in and around the Nyala Park conservation area, 7-12 March 2016. The list of possible species was compiled using distribution records and habitat descriptions from Happold (2013), Monadjem *et al.* (2015) and Skinner & Chimimba (2005). E, expected, Ne, not expected; F, found Nf, not found.**

| Species | Transect 1 Long grass, edge of seasonal floodplain | Transect 2 Woodland, grass undergrowth | Transect 3 Dense undergrowth around natural pool | Transect 4 Sugar cane adjacent to Nyala Park |
|---|---|---|---|---|
| *Graphiurus microtis* | Ne / Nf | E / Nf | Ne / Nf | Ne / Nf |
| *Beamys major* | Ne / Nf | E / Nf | Ne / Nf | Ne / Nf |
| *Cricetomys ansorgei* | E / Nf | E / Nf | E / Nf | Ne / Nf |
| *Saccostomus campestris* | Ne / Nf | E / Nf | Ne / Nf | Ne / Nf |
| *Dendromus melanotis* | E / Nf | E / Nf | Ne / Nf | Ne / Nf |
| *Dendromus mystacalis* | E / Nf | E / Nf | Ne / Nf | Ne / Nf |
| *Dendromus nyikae* | E / Nf | E / Nf | Ne / Nf | Ne / Nf |
| *Lophuromys machangui* | E / Nf | E / Nf | Ne / Nf | Ne / Nf |
| *Uranomys ruddi* | Ne / Nf | E / Nf | Ne / Nf | Ne / Nf |
| *Gerbilliscus leucogaster* | Ne / Nf | E / Nf | Ne / Nf | E / Nf |
| *Aethomys chrysophilus* | Ne / Nf | E / Nf | Ne / Nf | Ne / Nf |
| *Dasymus cf incomtus* | E / Nf | Ne / Nf | Ne / Nf | Ne / Nf |
| *Grammomys dolichurus* | Ne / Nf | E / Nf | Ne / Nf | Ne / Nf |
| *Grammomys ibeanus* | Ne / Nf | E / Nf | Ne / Nf | Ne / Nf |
| *Lemniscomys rosalia* | E / Nf | E / Nf | E / Nf | Ne / Nf |
| *Mastomys natalensis* | E / F | E / Nf | E / Nf | E / F |
| *Mus minutoides* | E / Nf | E / Nf | E / Nf | Ne / Nf |
| *Otomys angoniensis* | E / Nf | Ne / Nf | E / Nf | Ne / Nf |
| *Pelomys fallax* | E / Nf | Ne / Nf | Ne / Nf | Ne / Nf |
| *Thallomys paedulcus* | Ne / Nf | E / Nf | Ne / Nf | Ne / Nf |

**Table 44. Bats identified from echolocation recordings made at three general locations in the Elephant Marsh study area, 9-12 March 2016.**

| Illovo Sports Club, Nchalo | Nyala Park, Nchalo | Kaombe Launch area |
|---|---|---|
| Natal long-fingered bat *Miniopterus natalensis* | Sundevall's leaf-nosed bat *Hipposideros caffer* | Little free-tailed bat *Chaerephon pumilus* |
| Mauritian tomb bat *Taphozous mauritianus* | Hildebrandt's horseshoe bat *Rhinolophus hildebrandtii* | Angola free-tailed bat *Mops condylurus* |
| Yellow-bellied house bat *Scotophilus dinganii* | Mauritian tomb bat *Taphozous mauritianus* | |
| | Little free-tailed bat *Chaerephon pumilus* | |
| | Angola free-tailed bat *Mops condylurus* | |
| | Schlieffen's twilight bat *Nycticeinops schlieffeni* | |

### 9.3.4 Mammal sightings and signs

Fifty-two mammal species were directly or indirectly observed in the Elephant Marsh study area. Table 45 and Table 46 divides these sightings and signs into the four general areas Nyala Park (conservation area, north), Illovo Sports Club, sugar cane fields and Shire River bank, Nchalo (arthropogenically disturbed area), Shire River banks and islands in the flooded area, and the Nyasa Wildlife Sanctuary (conservation area, south). One should bear in mind that the amount of time spent in each of these areas was not nearly equal, and the number of people questioned in each area differed (e.g. in the "Shire River and islands, flooded area" the local people were only asked to confirm the identity of spoor). These species lists should, therefore, be taken as an indication of presence and not as a comparison between areas; more about this follows in Section 9.4.

The results of camera traps were included in Table 46 (Nyala Park). Here the cameras gave the following results:

**Camera 1**: Waterbuck *Kobus ellipsiprymnus* (4 videos; = *c*. 6% trap success);

**Camera 2**: Waterbuck *Kobus ellipsiprymnus* (3 videos), Blue wildebeest *Connochaetes taurinus* (2 videos) (= *c*. 7% trap success);

**Camera 3**: Nyala *Tragelaphus angasii* (5 videos; = *c*. 14% trap success);

**Camera 4**: Nothing (0% trap success)

The locations of species seen and or identified from spoor and scats at Nyala Park, Illovo Sports Club and next to the Shire River / flooded area are provided in Appendix 7B.

Only seven (7) hippopotamus individuals could be seen during the microlight flight in March (see Figure 59), meaning that the estimated number of hippos in the Elephant Marsh is most probably less than 100 (extrapolation of the March number observed brings the total number to between 40 and 60, but a few larger groups missed may mean that the numbers may be slightly higher). In comparison, at least 700 hippopotamus occur along the approximately 30-km stretch of the Shire River in Liwonde National Park, which also flows through large areas of marsh (JK Turpie, pers. obs., 2016). In the 1990s when there were still ±150 hippos residing in the river immediately in front of the Illovo Sports Club at Nchalo (Stewart Michael pers. comm.). More than 1 000 individuals probably would have occured in the Elephant Marsh under more natural conditions.

**Table 45. Mammals sighted and identified from signs (spoor, scats, runways, molerat heaps) at four general areas in the Elephant Marsh study area, 7-12 March 2016. Additional information for the Kaombe area and sugar cane fields was supplied by Mr. Stewart Michael (General Manager, Agricane) and Robert Nyrenda (CFC Nyasa Park wildlife guide), and for the Illovo Sports Club and sugar cane fields at Nchalo by sugar cane and security workers.**

| Mammal Species | Illovo Sports Club and sugar cane fields | Kaombe area and sugar cane fields | Shire River and islands, flooded area |
|---|---|---|---|
| **Order CARNIVORA** | | | |
| African wild cat *Felis silvestris* | YES | YES | |
| African civet *Civettictis civetta* | | YES | |
| Common large-spotted genet *Genetta maculata* | | YES | |
| Angolan genet *Genetta angolensis* | YES | | |
| African striped weasel *Poecilogale albinucha* | YES | | |
| Meller's mongoose *Rhynchogale melleri* | YES | | |
| White-tailed mongoose *Ichneumia albicauda* | | YES | |
| Water (Marsh) mongoose *Atilax paludinosus* | | | YES |
| Banded mongoose *Mungos mungo* | | YES | |
| Side-striped jackal *Canis adustus* | | YES | |
| Cape clawless otter *Aonyx capensis* | | YES | YES |
| Spotted-necked otter *Hydrictis maculicollis* | YES | | |
| **Order WHIPPOMORPHA** | | | |
| Hippopotamus *Hippopotamus amphibius* | YES (in Shire river) | YES (in flooded area close to boat launch site) | YES |
| **Order RODENTIA** | | | |
| Silvery mole-rat *Heliophobius argenteocinereus* | | YES | |
| Greater canerat *Thryonomys swinderianus* | YES | | |
| African marsh rat *Dasymys* cf *incomtus* | YES | | |
| Single-striped grass mouse *Lemniscomys rosalia* | YES | YES | |
| Natal multimammate mouse *Mastomys natalensis* | YES | | |
| **Order CHIROPTERA** | | | |
| Wahlberg's epauletted fruit bat *Epomophorus wahlbergi* | | YES | |
| Yellow-winged bat *Lavia frons* | YES | | |
| Natal long-fingered bat *Miniopterus natalensis* | YES | | |
| **Order CETARTIODACTYLA** | | | |
| Common reedbuck *Redunca arundinum* | YES | | |

**Table 46. Some of the larger mammals present in two conservation areas inside the Elephant Marsh study area, March 2016. Additional information for the Nyasa Wildlife Sanctuary at Kaombe was supplied by Mr. Stewart Michael (General Manager, Agricane), and that for the Nyala Park at Nchalo by Mrs. Jones Mwabekomo (Wildlife Officer) and Ellard Kombon (Wildlife Official). SL, present on the species list but not found during the current study.**

| Mammal species | Nyala Park, Nchalo | Nyasa Wildlife Sanctuary, Kaombe |
|---|---|---|
| **Order MACROSCELIDEA** | | |
| Four-toed sengi *Petrodromus tetradactylus* | - | YES (SL) |
| Dusky sengi *Elephantulus fuscus* | YES (SL) | YES (SL) |
| **Order LAGOMORPHA** | | |
| African savanna hare *Lepus microtis* | YES (SL) | YES (SL) |
| **Order RODENTIA** | | |
| Silvery mole-rat *Heliophobius argenteocinereus* | YES (SL) | YES |
| Cape porcupine *Hystrix africaeaustralis* | - | YES (SL) |
| Greater canerat *Thryonomys swinderianus* | YES | YES (SL) |
| Red bush squirrel *Paraxerus palliatus* | YES (SL) | - |
| Smith's bush (Tree) squirrel *Paraxerus cepapi* | YES (SL) | YES (SL) |
| Northern giant pouched rat *Cricetomys ansorgei* | YES (SL) | - |
| Fat mouse *Steatomys pratensis* | YES (SL) | - |
| Bushveld gerbil *Gerbilliscus leucogaster* | YES (SL) | - |
| African marsh rat *Dasymys* cf *incomtus* | YES (SL) | - |
| Creek grooved-toothed swamp rat *Pelomys fallax* | YES (SL) | - |
| Natal multimammate mouse *Mastomys natalensis* | YES | - |
| Pygmy mouse *Mus minutoides* | YES (SL) | - |
| Single-striped grass mouse *Lemniscomys rosalia* | YES (SL) | - |
| Climbing mouse *Dendomus* spp. | YES (SL) | - |
| **Order PRIMATES** | | |
| Greater (or Thick-tailed) galago *Otolemur crassicaudatus* | YES (SL) | YES (SL) |
| Yellow baboon *Papio cynocephalus* | YES (SL) | - |
| Vervet monkey *Chlorocebus pygerythrus* | YES | YES |
| Sykes' monkey *Cercopithecus mitis* | - | YES |
| **Order PHOLIDOTA** | | |
| Temminck's ground pangolin *Smutsia temminckii* | YES (SL) | - |
| **Order EULIPOTYPHLA** | | |
| Bicolored musk shrew *Crocidura fuscomurina* | YES (SL) | - |
| White-bellied hedgehog *Atelerix albiventris* | YES (SL) | YES (SL) |
| Bicolored musk shrew *Crocidura fuscomurina* | YES (SL) | |
| **Order CHIROPTERA** | | |
| Wahlberg's epauletted fruit bat *Epomophorus wahlbergi* | YES (SL) | YES (SL) |
| Mauritian tomb bat *Taphozous mauritianus* | YES | - |
| Little free-tailed bat *Chaerephon pumilus* | YES | - |

| Mammal species | Nyala Park, Nchalo | Nyasa Wildlife Sanctuary, Kaombe |
|---|---|---|
| Angola free-tailed bat *Mops condylurus* | YES | - |
| Sundevall's leaf-nosed bat *Hipposideros caffer* | YES | |
| Hildebrandt's horseshoe bat *Rhinolophus hildebrandtii* | YES | |
| Schlieffen's twilight bat *Nycticeinops schlieffeni* | YES | |
| **Order CARNIVORA** | | |
| African wild cat *Felis silvestris* | YES | YES |
| Serval *Leptailurus serval* | YES | YES (SL) |
| African civet *Civettictis civetta* | YES (SL) | YES |
| Common large-spotted genet *Genetta maculata* | **-** | YES (SL) |
| Angolan genet *Genetta angolensis* | **-** | YES (SL) |
| Slender mongoose *Galerella sanguinea* | - | YES (SL) |
| Water (Marsh) mongoose *Atilax paludinosus* | YES | YES |
| Banded mongoose *Mungos mungo* | - | YES (SL) |
| Dwarf mongoose *Helogale parvula* | - | YES (SL) |
| Side-striped jackal *Canis adustus* | YES | YES |
| Cape clawless otter *Aonyx capensis* | YES | YES |
| Spotted-necked otter *Hydrictis maculicollis* | - | YES |
| **Order PERISSODACTYLA** | | |
| Plains zebra *Equus quagga* | YES | - |
| **Order SUIFORMES** | | |
| Bushpig *Potamochoerus larvatus* | YES | YES |
| Common warthog *Phacochoerus africanus* | - | YES |
| **Order CETARTIODACTYLA** | | |
| Giraffe *Giraffa camelopardalis* | YES | YES |
| African buffalo *Syncerus caffer* | YES | YES (SL) |
| Blue wildebeest *Connochaetes taurinus* | YES | YES |
| Greater kudu *Tragelaphus strepsiceros* | - | YES (SL) |
| Nyala *Tragelaphus angasii* | YES | YES |
| Bushbuck *Tragelaphus scriptus* | YES | YES |
| Waterbuck *Kobus ellipsiprymnus* | YES | YES (SL) |
| Common (Southern) reedbuck *Redunca arundinum* | - | YES (SL) |
| Common duiker *Sylvicapra grimmia* | YES | YES |
| Suni *Neotragus moschatus* | - | YES (SL) |
| Impala *Aepyceros melampus* | YES | - |

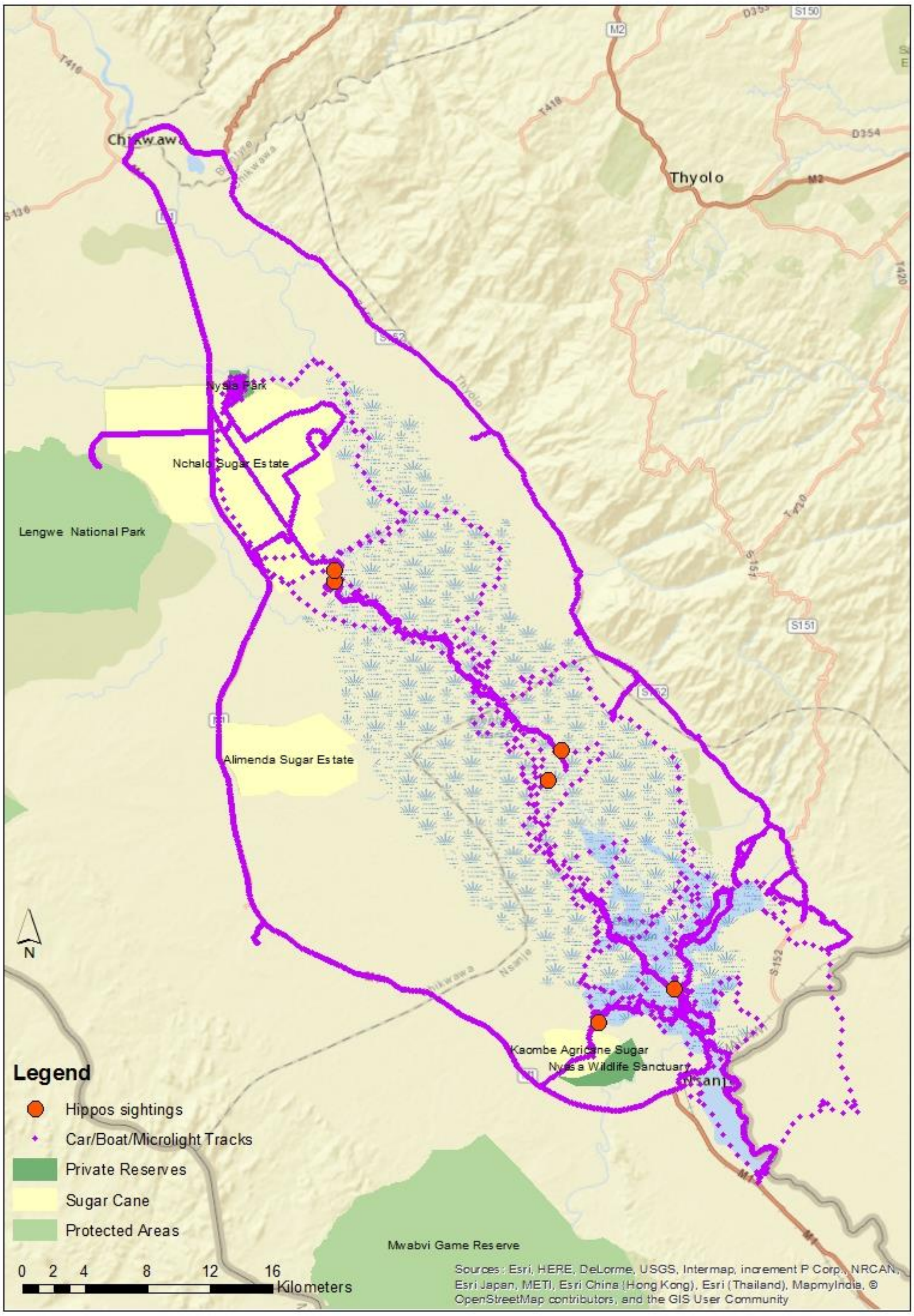


**Figure 59. Hippos sightings across all of the different fieldwork periods. The Pink dots and lines represent the coverage of areas based by boat/car and microlight. Details of the different sightings of hippos are provided in Appendix 7B.**

## 9.4 Present status of mammal fauna

The data gathered with different methods during the March 2016 field trip were consolidated in Appendix 7A, columns 3 and 4. Fifty-two mammal species were found inside the Elephant Marsh area, a mere sub-sample of what can be present in the Elephant Marsh today. Column 4 (Appendix 7A) gives a good indication of the species that we expect today in the Elephant Marsh, outside of the two conservation areas Nyala Park and Nyasa Wildlife Sanctuary. At least 108 species are expected to still occur in the Elephant Marsh area, with 37 more species considered as "uncertain/presence not impossible". Thirty-five percent of these 145 species are bats, 26% are rodents, 15% are carnivores, and 8% are bovids (all of which are considered as "uncertain" as the chances are good that some or all of them have already been hunted out).

Because of the hunting/consuming behaviour of the local people, many of the 108 + 37 species are expected to occur in very low numbers (if present). A large percentage (42%) of the 37 "uncertain" species can be considered as relatively easy to catch and highly sought after as food or for traditional purpose (e.g. aardvark, Cape porcupine, squirrels, ground pangolin and almost all bovids), and were found only in the protected areas Nyala Park and or Nyasa Wildlife Sanctuary. Eight (6% of) species that occurred here historically have been lost from the Elephant Marsh outside the two protected areas, and a further 19 (13%) are listed as presence "uncertain". Seven of the 8 lost species are currently listed by the IUCN as Threatened species, and so are 3 of the 37 "uncertain" species. Only one Threatened species (Hippopotamus, listed as Vulnerable) remains present at the Elephant Marsh, outside of the protected areas. Eight additional species + 3 "uncertain" species are currently listed by CITES (see Appendix 7A).

With such a number of species already lost and the presence of more species uncertain (even though they should occur in the specific habitats in the specific area) we can argue that the ecosystem is already under stress. The stress will be more pronounced if the species that are present are found in low numbers only; and even more so if those low numbers only occur in specific sub-areas. The fact that so many species are now found only in the protected areas make the above a realistic threat. The following observations made inside the "better covered" Nyala Park strengthen this claim as it propose that the integrity inside this reserve is also not as high as it could be and are an indication that the ecosystem does not function optimally:

1. Extremely low rodent and shrew trap success and species richness found in three habitats inside the conservation area;
2. Very low trap success and the few species captured with the camera traps;
3. Extremely low diversity of spoor, especially of carnivores;
4. Not one carnivore scat could be found in this park - which is low when compared to the relatively large number of African civet, Slender mongoose, Water mongoose, Side-striped jackal, Cape clawless otter and Spotted-necked otter scats found within *c*. 2 hours in the Nyasa Wildlife Sanctuary at Kaombe in the south;
5. Absence of porcupine quills or spoor agrees with the conservation officials' remarks that this species is not present inside the reserve or in the surrounding area;
6. Obvious absence of any mole-rat signs inside the park or in the surrounding area; in the Nyasa Wildlife Sanctuary, in the road outside, and on the edges of the sugar cane plantations at Kaombe mole-rat heaps were a common site;

7. The fact that some poaching does take place in this conservation area; and
8. The fact that firewood is gathered on a regular basis to fuel the refinery process at Illovo sugar estate.

Up until the late-1800s larger mammals roamed freely over and between neighbouring countries Malawi, Mozambique, Zimbabwe and Zambia, and into the study area. During the wet periods, when the marshes were flooded, these mammals (= a healthy community that included from the largest herbivores elephants and buffaloes, and carnivores lions, leopards and hyenas) would concentrate in larger numbers around the fringes of the marsh, while during the dry periods they would enter the then "dried-up" plains. Large groups of Hippopotamus would also have moved with the rising and falling water levels, but expanding their area of occupation in the flooded periods and decreasing in the dry periods, when they mostly concentrated close to the Shire River. The activities, scats and carcasses of all of these larger mammals would have contributed to nutrient recycling and energy flow in and throughout this dynamic ecosystem. In the water, however, the activities of hippopotamus would have played a major role in how the wetland system functioned; through their scats, but also how they moved both water and subsurface soil, and opened up new and existing channels making it possible for nutrients and other (smaller) organisms to spread more evenly over the entire area – which then directly and indirectly effected the ecosystem as a whole. The density of hippopotamus also changed drastically, but up to the 1990s there were still +/- 150 hippotami residing in the river immediately in front of the main club at Nchalo (Stewart Michael pers. comm.).

The smaller mammals also play a vital, intrinsic role in the ecosystem, but similar to the larger mammals would mostly have had to keep out of the water – meaning that the highest concentrations of rodents, shrews and sengis (≈ elephant shrews) would be above the flood mark; during the dry, non-flood, period a subset of the small mammal species would have infiltrated the dried-up area, starting from the flood mark, but then presumably they would occur in lower densities inside the marsh area. These "infiltrating" small mammals would have been followed by their predators. How far from the flood mark the smallest of these small mammals (e.g. mice and shrews) would have infiltrated into the "no man's land" we can only guess: if we assume that waves of immigrants may have followed after every new litter (*c*. every 30 days) and that every wave may wash into the next *c*. 100 – 200 m, we can expect that within a *c.* 7 month drying up period these small rodents might have covered a maximum distance of 1.5 km from the high water mark at the edges and on the higher islands – and that some of the marsh area (>100 km$^2$ of the inner area) might therefore seldom have experienced the presence of small rodents and shrews. The recovery of mole rats into the marsh area can be expected to be even slower than that of mice, with numbers of mole rats absent to very low in the central area.

The present mammal fauna is therefore far from the natural / historical, and the current ecological condition is considered degraded with "Little resemblance to the original state". While many of the historically present small mammal species may still occur in the area (see Appendix 7), the medium and large sized mammals today only occur in fenced protected areas. The small mammal communities in most of the area are also expected to be of low diversity, consist mostly of generalist species, and overall give an indication of low ecological integrity.

# 10 OVERALL STATUS AND PRIORITY AREAS FOR CONSERVATION

## 10.1 Overall status of biodiversity

The Elephant Marsh system has been significantly altered from its natural state in many different ways over the past 150 years. This has been largely due to increasing human pressure in the area of the marshes and their associated agricultural and natural resource use activities, as well as changes in the catchment affecting the quantity and quality of river inflows to the marsh.

Much of the marsh area has been transformed by cultivation, and most of the woody riparian species have been removed from the river banks and surrounding floodplain edges. These impacts are not of great concern in terms of plant species *per se.* No plant species encountered were of conservation importance or critically endangered. Aquatic plant species tend to have generalist life history traits to cope with their dynamic environment. Most species are therefore widely distributed and wetlands are not particularly species rich, and rare, specialised (those which are more likely to become endangered species) are not likely to be as common as in terrestrial habitats. The same can be said of wetland fauna. Nevertheless, the degradation and loss of wetland habitats has a significant impact on the capacity of the Elephant Marsh to support viable faunal populations, particularly of the larger species.

The degradation of aquatic habitats is reflected in the aquatic invertebrate community, which provides a good indication of overall ecosystem health. The aquatic invertebrate assemblage has probably shifted in favour of the more disturbance-tolerant species. The Odonata fauna observed in the region is made up solely of widespread species that are highly tolerant to changes in water levels and vegetation cover. The fauna thus does not appear to face particular threats and any changes will have limited local, national or global implications. Butterflies, on the other hand, rely more directly on the land surrounding the marsh, where they have been very negatively affected by human activities. This is potentially significant for the Lower Shire endemic race of Topaz Arab *Colotis amata* that was discovered in the study area.

Species of reptiles, amphibians and mammals which would have frequented floodplain areas around the marsh have been negatively impacted by loss of habitat as well as directly through hunting. Most large animal species have been severely reduced or are extinct from the area, which has altered ecosystem functioning to some degree. Waterbirds are still numerous, but their breeding areas have become more restricted and community composition has been altered.

It is also clear that direct harvesting has had a significant impact on biodiversity in the Elephant Marsh. For example, historical records show that two iconic reptiles of Malawi wetlands, the Zambezi Soft-Shell Terrapin *Cycloderma frenatum* and the Swamp Viper *Proatheris superciliaris*, both occurred in the Elephant Marsh region. They are in danger of becoming regional extinct, if not already so. Fish populations are subjected to high fishing pressure and are likely to be severely depressed, affecting their role in fisheries, and in supporting waterbird populaitons.

In spite of the fact that the Elephant Marsh system has been significantly altered and has lost much of its original wetland and floodplain area to agricultural use and human settlement, it still contains large enough areas of functional marshes and floodplain habitats to support significant biodiversity and ecosystem services. The populations in these areas have been impacted on by direct harvesting, however, as much of the study area is accessible by foot or mokoro. Only a small proportion of the original Marsh area remains relatively unimpacted. Nevertheless, wetlands and their fauna are naturally fairly resilient. The Elephant Marsh is therefore considered to be in a D category in terms of its overall health.

**Table 47. Ecological condition of Elephant Marsh biodiversity components.**

| Group | Description | Rating |
|---|---|---|
| Vegetation | Largely modified | D |
| Aquatic Invertebrates | Moderately modified. | D |
| Odonata | Slightly modified. | B |
| Butterflies | Seriously modified | E |
| Reptiles & Amphibians | Moderately to largely modified. | C/D |
| Fish | Moderately to largely modified. | C/D |
| Birds | Slightly to moderately modified | B/C |
| Mammals | Seriously modified | E |
| **Overall** | **Largely modified** | **D** |

## 10.2 Priority areas for conservation

The most valuable parts of the marsh in terms of biodiversity are the areas in which habitats have been least transformed, and in which disturbance is minimal. But it is the combination of different types of habitats within the marsh that give it its overall conservation importance, as many species rely on the juxtaposition of different types of habitats for their survival.

Because wetlands are dynamic, it is not wise to pinpoint priority areas with too much geographic precision. The functional areas of the marsh will vary as hydrodynamic patterns change over time.

Currently, species diversity in the Elephant Marsh increases downstream, as habitat heterogeneity increases, and the lower half of the Marsh is richest in biodiversity. This area contains a variety of habitats, notably including the productive lake or lagoon areas, as well as a relatively undisturbed core area. However, these areas are not well connected to the floodplain, as there is little intact floodplain left anywhere around the Elephant Marsh.

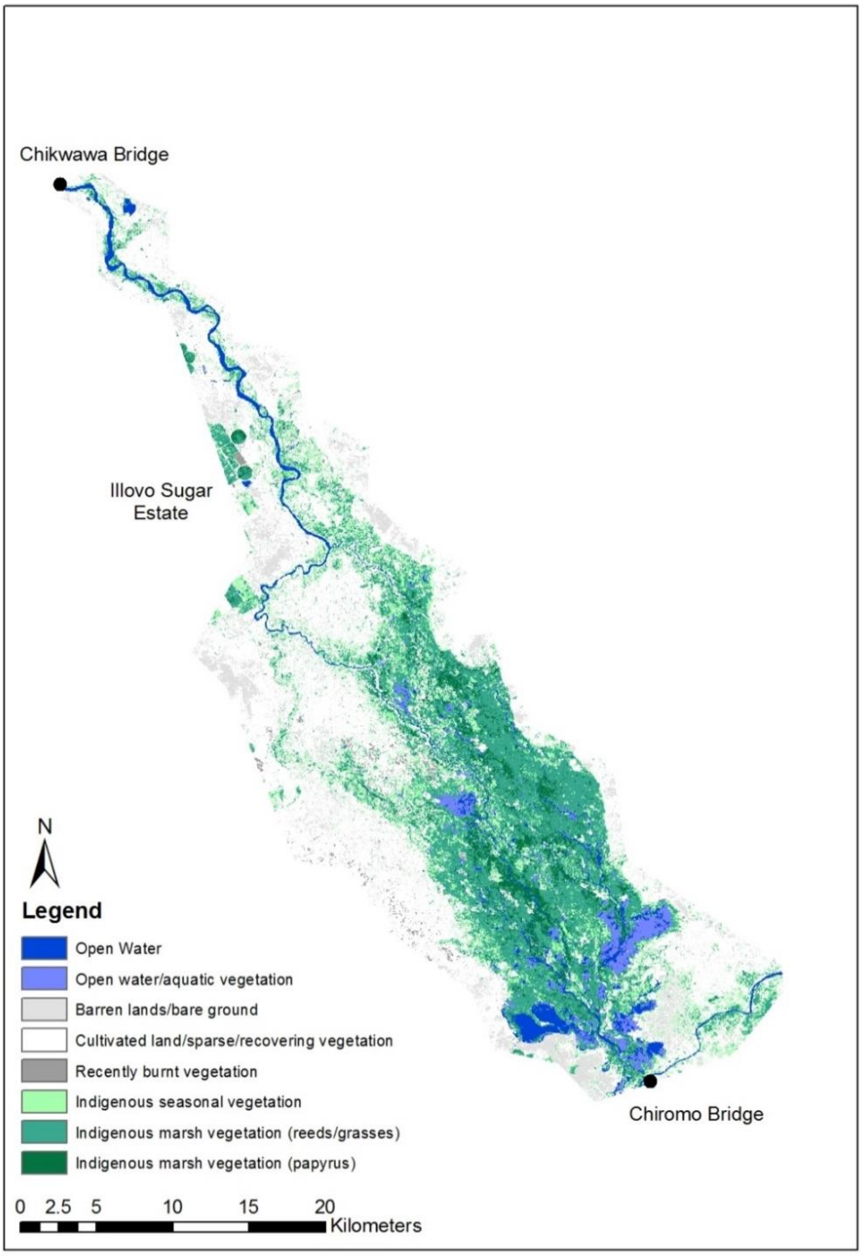


**Figure 60. Vegetation map of the Elephant Marsh**

For terrestrial groups such as butterflies, the higher mounds near the lake shore which held reasonable plant diversity, including a few trees such as the *Phoenix* palm, as well as the better-preserved natural habitats at Illovo (Nyala) and Kaombe on North/South of the West Bank, were important areas of biodiversity.

# 11 MAIN THREATS TO BIODIVERSITY

## 11.1 Loss of natural vegetation in catchment

The main overall threat to the Elephant Marsh is the growing human population, not only directly surrounding the marsh but within the catchment and Malawi as a whole. This has led to increased water abstraction, conversion of land to agriculture, soil disturbance, increased sediment inputs into rivers, and concomitantbiodiversity losses. The decrease in natural vegetation and reduced filtering capacity of vegetation across the catchment has resulted in increased peak river flows that damage infrastructure (e.g. roads erosion and bridges washing away) and interupts farming within the catchment through the loss of fertile topsoil. These increased sediment loads move down into the Shire River and the Elephant Marsh. The resultant high turbidity levels reduce the productivity of littoral zones, smother substrates, and reduce food source availability and fish visibility (which can affect hunting for many species). Hanmer (1977, for example, mentions increased turbidity in the Shire River and the potential affects on both fish and waterbirds. The consequences of these anthropogenic disturbances will have a considerable negative impact on fish and in turn the human food source. In 1990, the value of the Elephant Marsh purely in terms of the fish harvested was estimated to be USD$1.11 million/annum, and the prices of fish in the region has increased considerably since 1990 (Kosamu *et al.* 2012).

The riverine ecosystems, such as those in the inflowing tributaries are considered to be resilient to disturbances such as annual floods, with recovery time dependent on the type, scale and duration of the disturbance (Milner 1996). The disturbances experienced within these systems as a result of changes in the catchment include increased sedimentation, channel modifications as a result of sediment inputs, increases in peak flow intensity, decrease in annual river flows and decreased buffering capacity of riparian zones. According to Milner (1996), catchment scale disturbances can take more than 20 years to recover. This is supported by Madej & Ozaki (2009) who state that rivers exposed to high sediment inputs take considerable time to recover, since recovery is dependent on remedial actions on a catchment scale as well as the downstream movement of sediments already in the system.

## 11.2 Upstream developments and flow modification

One of the main threats to the Elephant Marsh are the as yet unknown implications of the planned abstractions from the Shire River and the proposed changes to the hydropower production of the the Kapichira Falls Hydroelectric Power station and elsewhere. The Environmental and Social Impact Assessment for the Shire River Irrigation Project (Deneut & Pahin 2015) is currently underway but does not include a substantial assessment of Ecological Water Requirements. Reduced flow through the Elephant Marsh will reduce the extent and flooding of lake and permanently inundated habitats as well as lessen the extent (and possibly frequency) to which the flood plain is flooded. These changes will affect the biodiversity of the Elephant Marsh directly as flow, sediments, vegetation and marsh fauna are intricately linked. Reduced flow through the Elephant Marsh will also facilitate encroachment by people and increase the extent of cultivation and natural resource harvesting. The marsh and lakes habitats are currently the least impacted and the current levels of subsistence cropping, fishing and harvesting from these habitats seem sustainable. This will not be the case if proposed abstractions and further regulation of Shire River flow go ahead without due consideration of the Environmental Water Requirements for the Elephant Marsh to understand the ecological and social ramifications of these developments for the marsh and downstream areas.

Aquatic plants are reasonably resilient to changes in stage (water depth) but their abundance will decrease proportionally with reduced extent of the lakes. Similarly, marsh vegetation will be impacted by reduced flow as drying will reduce the ability of marsh plants to resprout and therefore to persist and will also make it easier to clear marsh areas for cultivation. There are few undisturbed river channels and little woody plant vegetation in general. The non-woody plant species that inhabit river banks are reasonably resilient to being cleared, resprouting vigorously in response to cutting and being able to disperse and re-populate new areas quickly. Shrubs are less resilient than reeds and grasses but more so than trees, the least resilient and slowest to re-establish if given the chance. There are few sources of seed or cuttings from which to initiate a river bank restoration, should this be attempted. Such an exercise would only succeed if the villagers subsisting off, and in, the marsh be willing participants. There is little understanding amongst the local villagers of the ecological benefits of well vegetated river banks, comprised of trees and shrubs, versus their need for building materials, fuel in the form of coal and the space for cultivated crops. The remaining portions of floodplain on the western bank are being targeted for irrigated agriculture. Floodplains generally consist of graminoids (grasses, sedges and reeds) all of which are reasonably resilient to cutting, being resprouters, so under subsistence agriculture floodplains are reasonably resilient to grazing and cutting.

Reduced flow through the Elephant Marsh will reduce the extent and flooding of lake and marsh and floodplain habitats, affecting in particular fish species with a strong dependence on the seasonal floodplains, e.g. Mozambique tilapia and the sharptooth catfish. In scenarios of extreme low flow for prolonged periods, predation by tigerfish and catfish is likely to reduce the overall abundance of many prey species, with knock on effects to fishery yields, and the birds and crocodiles that prey on these species.

Hanmer (1977) mentioned how the upstream construction of dams (especially the Liwonde Barrage) had affected river flow dynamics, with potential impacts on waterbird populations. Artificial changes in flow have previously had significant impacts on fish populations in the Elephant Marsh. In 1978 a sudden closure of Liwonde Barrage resulted in a rapid reduction in flow in the Middle and Lower Shire. Reduced flow was observed at Chikwawa within two days of the barrage closure, although the marsh outlows at Chiromo fell more slowly over a period of three weeks. This delay was due to the draining of water from the floodplain, which resulted in massive fish mortality in the marshes the main river channels as a result of stagnant, deoxygenated water draining from under the marsh vegetation (Tweddle 2015b). Similar, but naturally occurring, fish mortalities on much more localised scales are reported regularly from the papyrus swamps of the Okavango Panhandle and from the lower section of the Caprivi floodplain on the Upper Zambezi River when floodwaters rise and flush out stagnant water from under previously grounded papyrus mats (Bills 1996; Tweddle *et al.* 2003).

Whilst the impacts of reduced or modified flow on fish may be significant, with important short term consequences for fishing communities and other biodiversity groups, many species are resilient and fish communities are likely to recover if flow regimes are returned to natural conditions. Evidence for relatively rapid recovery (i.e. < 5 years) of fishery species is provided in (Tweddle 2015b) and from similar observations of flow changes and reversals (Bills 1996; Welcomme 1985). However, major and permanent reductions in flow can be expected to increase the vulnerability of some species to overexploitation by fisheries or environmental shocks, especially those sensitive to levels of dissolved oxygen and sedimentation loads, or those dependent on access to floodplains. Similarly, it is not clear how resilient depressed fish communities will be to future changes in the climate.

## 11.3 Increased human encroachment, burning & cultivation

Human development cannot continue on the current trajectory without large-scale changes in the ecosystem services that underpin human well-being (Poppy *et al.* 2014). The linkage between ecosystem services and food security is of particular concern in Malawi, which is experiencing rapid population growth and significant land-use change. The population of the country has more than quadrupled in 50 years, and is predicted to exceed 45 million by 2050. While the Elephant marsh was relatively undisturbed when the area was declared a game reserve the area now has a human population totalliong over 750 000 (National Statistics Office, Malawi). Indeed, within the two districts surrounding the Elephant Marsh there has been a 40% increase in population size in the past 20 years. The Elephant Marsh is now heavily degraded by a range of anthropogenic impacts, and these are expected to increase with the national demographic and economic forecasts (Poppy *et al.* 2014).

The floodplain edge is increasingly encroached by human settlements, over-grazing by livestock, and further development of subsistence farming and market gardening, particularly rice paddies (Figure 61) and other cash crops. Prior to habitation the area of natural unmodified marsh would have been some twice the current extent. The more transformed areas are the marsh edges, which would otherwise be particularly productive floodplain habitats waterbirds, reptiles, amphibians, fish and mammals.

The frequency of fires during dry periods in the marsh and surrounding areas has likely increased with burgeoning numbers of people and their ongoing encroachment into the marsh. This burning also dries papyrus marsh, which further enables the encroachment of people and cultivation. This practice of regularly burning the seasonal floodplain has caused extensive habitat loss and modification (Figure 62) and threatens mammal, reptile and amphibian populations which often cannot vacate quickly enough to escape the fire.

Crocodile-human interactions will increase if human numbers and encroachment into the remaining uncultivated regions of the Elephant Marsh persist. This will be exacerbated as fish stocks, the natural food of crocodiles, dwindle and crocodiles have to hunt for alternative prey.

**Figure 61. A view from the microlight surveys of intensive cultivation in Elephant Marsh (Photo: D. Allan) and conversion of the floodplain of the Elephant Marsh into rice paddies (Photo: W. Branch).**

**Figure 62. Fire appears to be used to facilitate the establishment of new cultivated fields in Elephant Marsh during dry periods, as apparently visible here from the microlight flights (Photos: D. Allan). Fires were witnessed on all the field trips, and people were seen deliberately lighting these fires and cultivating the recently burnt areas (Photos: W. Branch).**

## 11.4 Tree felling

There has also apparently been a great reduction in tree cover throughout the marsh area, previously concentrated along river channels (Figure 63) and in infrequently inundated woodlands that usd to surround the floodplains. Waterbirds that typically favour tree-lined watercourses, e.g. African Finfoot, White-backed Night Heron and Green-backed Heron, are current absent/rare in the Elephant Marsh This coupled with reduced seasonal flooding of floodplain and marsh habitats further reduces favourable waterbird habitat. Parts of the surrounding woodlands would also have been inundated, albeit it less frequently, but the extent to which temporarily inundated woodland, utilised for nesting by large colonially breeding waterbirds remains unknown. Eveneven solitarily nesting species, such as Hamerkop, Hadeda Ibis and African Pygmy Goose, are likely affected.

**Figure 63. Tree felling in the Elephant Marsh area as noted from the microlight surveys (Photo: D. Allen).**

## 11.5 Commercial sugar-cane farming and agro-business

The large commercial sugar-cane estates on the edge of the marsh are located in what would have been floodplain but also impact the marsh through water extraction for irrigation erosion and potentially the runoff of agro-chemicals (pesticides and fertilizers) into the wetland, raising the possibility of contamination and eutrophication from these sources (Figure 64). These large estates have also been at least partially responsible for the influx of large numbers of humans (as employees and their dependents) into the immediate area (Hanmer 1977).

While floodplain vegetation can be somewhat resilient to subsistence agriculture, commercial agriculture tends to transform soils and more effectively remove indigenous species through mechanical clearing, ploughing of fields and the use of herbicides and pesticides. This decreases the likelihood that unassisted natural recovery may take place where this occurs.

Hanmer (1977), however, points out that in some ways the irrigated sugar-cane plantations act as artificial 'marshes' providing habitat, including breeding habitat, to a wide range of birds, including waterbirds. She stresses that protection from human disturbance is a particularly valuable aspect of these anthropogenic habitats. But as the wife of a sugar-cane estate employee, perhaps her perseptions in this regard were not without some level of subjectivity.

If the development of agro-business, with extensive rice plantations and even sugar cane plantations within the wetlands, is restricted to relatively small areas with intervening natural corridors it may not significantly affect faunal groups such as amphibians. Although the preparation of extensive sugar cane fields causes considerable habitat destruction, it is high-intensity agriculture in a well-circumscribed area. Moreover, due to the relatively long standing crop period, many fossorial reptiles and amphibians have been shown to be relatively tolerant of sugarcane production (Johnson & Raw 1989). The maintenance of a system of drainage channels in the sugar plantations also provides corridors for movement by aquatic species and also breeding habitats for many small amphibians. The presence of permanent water bodies may also stimulate populations of species that have extended larval development (e.g. *Kassina maculata*) or require permanent water (e.g. the tropical platanna *Xenopus muelleri*). There was no obvious evidence of visible pollution within the vicinity of the permanent or temporary local villages. However, the use of herbicides and insecticides during sugar cane production can be expected to increase and should be monitored. These may add to current expectations that only generalist small mammal species occur in these agri-ecosystems and that the carnivore guild is depauperate.

**Figure 64. A view from the microlight survey of the extensive irrigated sugar-cane estates at Nchalo and water extraction pumping station on the Shire River just above Elephant Marsh as viewed from the microlight flights (Photos: D. Allan).**

## 11.6 Fishing

Fishing pressure is intense in the more dense populated northern and southern parts of the marsh, although less so in the more inaccessible central and western areas (Figure 65 and Figure 66). However, given the size of the marsh the current fish populations seem to be still mainly functional, despite changes to biodiversity.

This fishing activity, however, negatively impacts waterbirds through competition for fish resources, direct disturbance from human fishermen, and drowning and entanglement in fishing nets, especially gill nets, and fishing tackle. A noticeable feature coming out of the waterbird counts made and reviewed during this survey was the absence or scarcity of several species of diving waterbirds, e.g. Little Grebe, White-backed Duck and Pygmy Goose. These species might have been expected to be common at the marsh given the ubiquity of apparently suitable habitat. Drowning in the equally ubiquitous gill nets set virtually throughout the marsh could be responsible for in this absence/scarcity. It should be noted though that the Reed Cormorant, a diving species, was common.

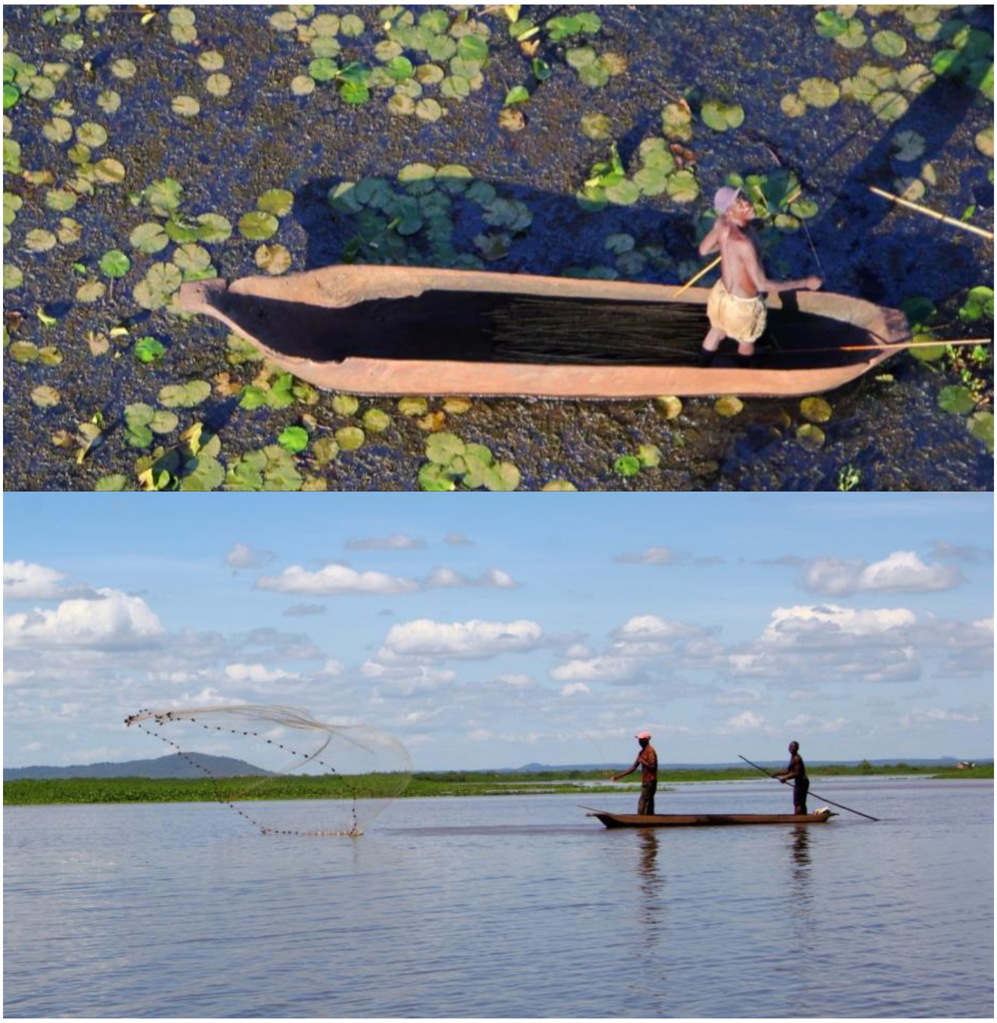

**Figure 65. A fisherman laying gill nets in Elephant Marsh as noted from the microlight surveys and a throw-net being deployed on one of the large lower lagoons at Elephant Marsh (Photos: D. Allan).**

**Figure 66. A large fishing net noted during the microlight flight that appears to be made of several mosquito nets sewn together, fish traps being transported and a fish-barrier trap erected across a section of Elephant Marsh, as noted from the microlight surveys. Such structures are ubiquitous virtually throughout the marsh (Photos: D. Allan).**

The piscivorous component of the aquatic avifauna also seemed dominated by species that feed on small fish, e.g. Reed Cormorant, small- to medium-size herons and egrets, and Pied Kingfisher, with the larger piscivorous species likely to feed on larger fish proportionately less prevalent, e.g. White-breasted Cormorant, African Darter, Pink-backed Pelican, Goliath Heron, Yellow-billed Stork, and African Fish Eagle, although water depth may also a reason for some of these differences.

Waterbirds are known to be particularly sensitive to disturbance. Fishing is likely to be the primary source of disturbance to waterbirds in Elephant Marsh, although other activities such as cultivation, temporary habitation, vegetation harvesting, etc., are also relevant in this regard (Figure 67). This disturbance could apply to both foraging and breeding waterbirds, and especially waterbird species that breed colonially.

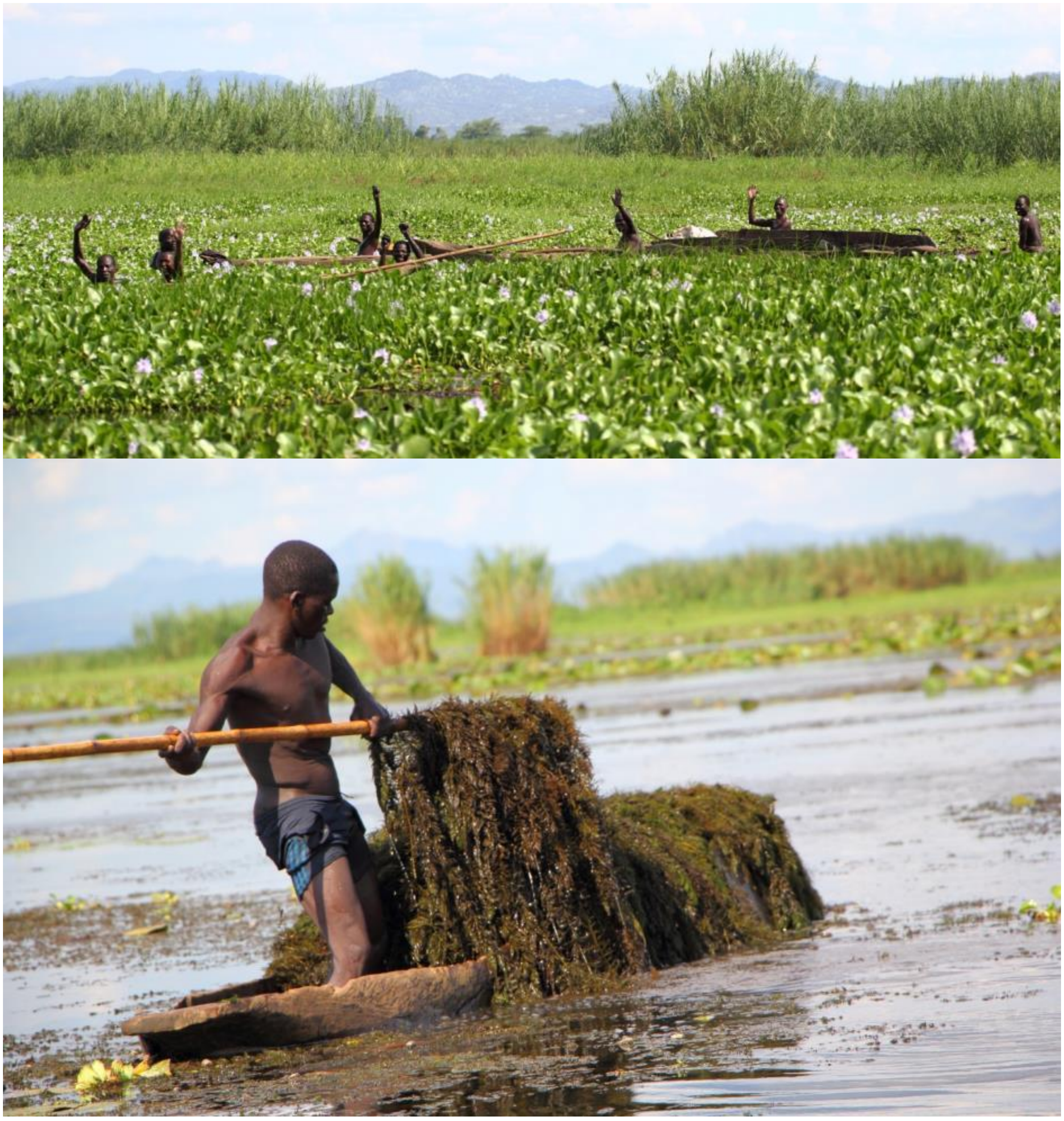

**Figure 67. Local community members gathering natural resources and the harvesting of aquatic (submergent) vegetation at Elephant Marsh (Photos: D. Allan).**

The high levels of human disturbance in the marsh could negatively impact, potentially to a profound degree, waterbird species that breed in colonies, or even singly, in the marsh, including those that nest in trees or reedbeds, but perhaps especially those that nest in exposed positions at ground- or water-level, e.g. African Jacana, Black-winged Stilt, Long-toed Plover (Figure 68), Whiskered Tern and African Skimmer. The potential threat from human disturbance to breeding African Skimmers at their exposed sandbank nesting colonies would be of the greatest anxiety in this regard, given that this is a species of global conservation concern and the only such species for which Elephant Marsh is a significant site.

**Figure 68. Long-toed Plover at Elephant Marsh; a species potentially vulnerable to human disturbance when breeding (Photo: D. Allan).**

## 11.7 Alien species

Invasive alien floating weed species such as water hyacinth *Eichornnia crassipes,* water lettuce *Pistia stratiotes* and water fern *Azolla filliculoides* are very abundant across the Elephant marsh, sometimes forming large mats that almost completely cover smaller lakes (Figure 69). The source of these weeds is likely from barrages and dams upstream, which then float down into the Elephant Marsh, or from seeds or plant propagules collected on bird feet in neighbouring aquatic systems and delivered to the marsh. These aquatic weeds are known to infest tropical waterways worldwide. Predominance of these weeds canclog waterways, change drainage patterns and lead to low oxygen levels in the water which can be detrimental for aquatic invertebrates and fish species. These alien invasive plant species, of which water hyacinth *Eichornia crassipes* is likely the most predominant, could have profound ecological impacts on the wetland avifauna by reducing habitat for species such as White-backed Duck and Pygmy Goose. These areas may however provide favourably habitat for other species, such as the Openbill Stork (Figure 69).

**Figure 69. Large areas of Elephant Marsh are infested with alien invasive water hyacinth *Eichornia crassipes*, which nevertheless seems to be a favoured area for Openbill Storks, as visible here from one of the microlight surveys (Photo: D. Allan).**

## 11.8 Hunting/poaching

As seen with so many other poor communities in Southern Africa (see e.g. Avenant *et al.* 2014), the wildlife in the immediate area is an important source of food and of traditional use. This poaching and illegal harvesting also takes place around and inside the protected areas inside and around the Elephant Marsh area. This is probably one of the most important threats to the mammalian fauna of the Elephant Marsh where the habitat is not fenced, where people utilise marsh habitats daily, and the area is difficult to police. Education may play an important part in dealing with this specific problem, but one should look for other incentives that will replace "the loss of food and other articles" provided by poaching.

Intense hunting and trapping pressure on waterbirds directly takes place at Lake Chilwa in Malawi, particularly at times when fish resources are low (van Zegeren & Wilson 1999). Whether similar hunting and trapping of waterbirds occurs at the Elephant Marsh is not known, although Hanmer (1985) states that in: "the Lower Shire Valley the shooting season for duck ends 31 January" when apparently referring to sport hunting in the context of querying the timing of the hunting season relevant to waterfowl breeding seasons in the region. Little evidence of such exploitation was noticed, however small birds seen sold on sticks as meat in markets have been seen, and as such this issue is likely worthy of further attention.

## 11.9 Loss of mammalian megafauna

The original mammalian megafauna that once inhabited the marsh, e.g. species such as elephant, hippo (Figure 70) and buffalo, have now been entirely or largely extirpated. These megafauna would have played an ecological engineering role in the functioning of the marsh through nutrient cycling and maintaining marsh channels.

The protection of hippopotamus in the Elephant Marsh is a serious concern. Their damage-causing behaviour, threat to the local people, and the fact that they provide a large amount of meat and fat make the hippopotamus a target species. The main problem with hippopotami is that they require inundated areas during the day, but often travel large distances at night to graze dry land. While there are plenty inundated channels for them to seek refuge during the day, they are severely limited in areas where they may graze safely, such as un-cultivated floodplain areas. As a result planted fields are regularly raided and National Parks personnel currently cull problem individuals when complaints are lodged. Crops planted directly on the river banks often use a rudimentary form of fencing, 'scarecrows' or have people whose job is solely to deter hippo stationed permanently at the fields in order to limit crop damage (Figure 70). These practices are concentrated at river banks and it is not certain how effective they are. Currently there are few uncultivated floodplains where hippo can graze, nor are there refugia or breeding areas other than the most inaccessible areas of the marsh.

It is estimated that the total area could support between 500 and 2000 hippos, and where there were c. 150 hippos just around the Illovo Sports Club, Nchalo, in the 1990s, there are now estimated less than 100 individuals remaining. These mammals in particular play a vital part in maintaining channels through vegetation such as papyrus that divert flow through the marsh. Within the Okavango Delta, the hippopotamus is thought to play a crucial role in the development of new channels, which divert flow and sediments into backwaters areas (McCarthy *et al.* 1998). Anecdotal evidence from fishermen suggest that the marsh is much less 'open' and contains fewer small channels than previously occurred, which has made it difficult to access backwater areas off the main channel . It is, however, not certain whether the hippopotamus plays the same role in the Elephant Marsh ecosystem, nor how the decline in that function would balance against increased sedimentation, or diversion of flow in the main channel.

Hippopotamus as well as other large herbivores would have played an important role in the systems nutrient cycling. These animals forage in the floodplains (or farther afield in the case of many species) and introduce these new nutrients into the wetland via heir dung. This addition of nutrients in this way is now limited, however its net effect may be masked by other sources on nutrient input such as sugar cane run-off or through increased sedimentation in the system.

**Figure 70. Only small numbers of hippo were noted in Elephant Marsh during the microlight flights top (Photo: D. Allan) hippo deterrent fencing along Shire banks (Photo: K. Forsythe).**

# 12 RECOMMENDATIONS

## 12.1 Apply for Ramsar status

One of the primary recommendations of this study is that an application to have Elephant Marsh designated as ‘a wetland of international importance’ under the Ramsar Convention should be formally pursued. This would focus critical national and international attention on this significant and valuable wetland in order to ensure that it is managed in a sustainable manner meeting both human and biodiversity needs.

If Ramsar designation takes place, it will also be imperative to prioritise sections of the marsh for conservation of biodiversity. This would also include a focus on the lakes in the lower Marsh, as these are some of the most critical habitats for the large populations of waterbirds. This poses some potential conflict, as these are also some of the more highly utilised for fishing. While Ramsar sites do not have to be excluded from all human activities or be formally protected, it would be wise to limit fishing in order to lessen disturbance to waterbirds.

## 12.2 Secure environmental flow requirements

In order to ensure that future projects and developments upstream of the Elephant Marsh do not disrupt the functioning of the system and any newly designated conservation area, an Environmental Flow Assessment should be conducted for the Shire River and the Elephant Marsh (as well as other large marshes downstream such as the Ndinde Marsh). Such an assessment would determine the minimum flows and water quality needed to sustain a healthy and functioning marsh.

It is important that a comprehensive environmental flow assessment be undertaken for the expansion of irrigated agriculture along the western bank and increased capacity at the Kapichira Falls Hydroelectric Power station. There is little value in delineating areas of conservation importance in the Elephant Marsh if flow in the Shire River is going to be further compromised.

The Elephant Marsh is relatively resilient as a floodplain ecosystem, but with the deterioration of the catchment as a whole, the loss of refugia and continuous negative influences will have a major impact on recovery times. Determining and securing environmental flow requirements and improving catchment management is therefore a priority. Catchment management can be improved by maintaining riparian zones and their buffers, improving erosion control efforts, improving agricultural practice and road management and maintenance and also educating the people about aquatic ecosystem functioning.

## 12.3 Afford high level of protection to priority areas

Despite its potential conservation importance, human pressures on the Elephant Marsh are extremely high, and restoration of the Elephant Marsh would be an unrealistic goal. Instead it is recommended that an effort is made to protect and improve the health of remaining marsh area, particularly the lower half of the Marsh. The protected area needs to be of sufficient extent to conserve viable populations, and to maintain the supply of ecosystem services. Currently, the most naturally-functioning and least disturbed lakes and marsh are found in the centre and southern portions of the Elephant Marsh, largely due to their being permanently inundated and difficult to access (*mokoros* can only cover relatively short distances in one day). These less disturbed habitats are presently supporting source populations of species that sustain the livelihoods of the local villagers so the social benefits of preventing degradation of these habitats would be significant. This part of the Marsh ideally needs to be declared as a no-go area in order to maintain natural ecosystems, but other factors may need to be taken into account in order to develop a successful strategy.

## 12.4 Create conservation corridors

There are a number of conservation areas in and around the Elephant Marsh, but there are no safe corridors that connect them. In one instance, between the Nyala Park and Lengwe National Park, a river forms a natural corridor – but it is not safe for animals to move/migrate. Fencing of these reserves are another problem: while the specific type of fence at Nyala Park and Nyasa Wildlife Sanctuary do allow the small mammals to pass through, the medium-sized to large mammals are effectively kept inside, or outside, and no migration can take place – also not for hippos that may seek the safety of the protected areas inside the Elephant Marsh area. This issue needs to be addressed, especially if populations of larger mammals are to be maintained within the Elephant Marsh area (this issue is currently receiving attention at the Nyasa Wildlife Sanctuary (S. Michael, pers. comm.).

The biodiversity of the greater Elephant Marsh system would also be bolstered by maintaining corridors between the different habitats across the marsh including the permanently inundated areas (lakes, marsh and river channels), the seasonally inundated floodplains and fringing woodland habitats. These connections would facilitate movement of animals in and out of the marsh as well as providing some additional refuge from human disturbance and exploitation.

There are currently two private conservation areas that border the marsh (Illovo's Nyala Park and Kaombe Ranch's Nyasa Sanctuary) which could be opened up to the marsh more to allow movement of animals in and out of the marsh. These counld form connections with any newly established conservation areas within the marsh. While doing so would also need to coincide with heightened protection in terms of excluding people and/or preventing poaching, it would be especially beneficial to larger mammalian species which are not persisting outside of conservation areas.

In addition, the lateral connectivity of alluvial rivers is considered key to the ecological integrity of the Elephant Marsh (Ward & Stanford 1995). Better management of the tributaries of the Shire and their inclusion in the creation of conservation corridors would likely have a positive effect on aquatic biodiversity in the region in general.

## 12.5 Improve management of surrounding impacted habitats

Further destruction of the functional elements of the Marsh, particularly the use of dry season fires to promote access to the extensive papyrus beds, should be banned. In addition, soil conservation practices should be encouraged and efforts to halt deforestation should be implemented. These goals are extremely difficult to achieve, but progress is being made in the development of effective policy measures. Effort should be made to design effective meaures based on evidence from experiences elsewhere.

## 12.6 Improve management of utilised populations

The continued removal of eggs from wild crocodile nests should be allowed only following a census of crocodile numbers and natural recruitment to show what the current levels of off-take are sustainable. High levels of egg off-take (5000 eggs (120 nests) per annum by Shire River Crocodile Farm) may be sustainable if mitigated by the release of captive-reared juveniles, in numbers calculated from projected survival rates of juveniles. Similarly the removal of adult crocodiles for breeding stock at commercial crocodile farms must be supported by research on crocodile numbers in the system to confirm sustainable levels of offtake.

In order to improve fisheries management, it is recommended that a programme of environmental education is devised for government officials and key stakeholders involved in fisheries and natural resources management that is specific to the management of the resources of the Elephant Marsh and its surroundings. This would cover the biology and ecology of the species involved, monitoring methods, management objectives and management responses.

## 12.7 Research and monitoring

Regular monitoring is needed in order to determine the rate and scale of environmental change in the Elephant Marsh. Whilst it is relatively easy to draw up monitoring programmes that are designed to answer complex questions, it is much more difficult to carry out and sustain such programmes. Long-term monitoring programmes are often implemented poorly, usually because they are too ambitious and local institutions, which ultimately have to carry them out, lack the capacity to do so. A monitoring programme should therefore be designed to use simple equipment that can be maintained locally; it should also be suitable for junior or new staff to undertake with minimal training, which can be provided by other staff experiences members. It should focus on gathering information on relevant indicators of known environmental impacts, including changes in flow, sedimentation, and fishing, as well as expected emerging threats, such as pollution.

In general, additional research on all the biotic groups would help to improve management decisions over time. Systematic monitoring of biodiversity should also take place. For example, crocodile numbers and recruitment in the Elephant Marsh and adjacent sections of the Shire River should be regularly monitored (minimum of a 2 year cycle) in order to ensure survival of the existing populations.

## 12.8 Change means of problem animal control

The hippopotamus population of the Elephant Marsh is under serious threat from poaching and the culling of 'problem animals'. While the problem of hippos raiding crops is very real one, and food supplied by hippos welcomed by local inhabitants, the problem has arisen because humans have encroached on the hippos natural grazing lands. Unless the people of the marsh can find a way to co-exist with hippos, through the use of effective deterrents and safe guarding of crops, it is likely that hippos will soon be eliminated from the Elephant Marsh or become infrequent visitors (if other neighbouring marshes can sustain them). While recovering the hippo population to pre-disturbance or even mid-twentieth century size seems unrealistic given the lack of uncultivated grazing land, the marsh could still support a healthy population in a designated conservation core area. The presence of these large animals is important to nutrient cycling within the marsh, as well as maintaining smaller channels.

In order to try and conserve the hippo population of the Elephant Marsh there needs to be a more effective protocol on culling for human-wildlife conflict mitigation (rather than shooting an animal whenever a resident makes a complaint. This would need to be done in conjunction with close monitoring the population as well as seeking to establish (or enlarge e.g. the Nyala Park and Nyasa Wildlife Sanctuary) so that they include a part of the major river(s) and have a safe (patrolled) entrance for hippos. Additionally, making use of known effective methods (e.g. knee high wire/cables) to keep the hippos from specific areas can lessen the degree of human-wildlife conflict.

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# Appendix 1: Vegetation

A complete plant species list for the Elephant Marsh is presented below. Forty five (16%) of the 283 species were found to be exotic. None of the species identified were near-threatened or of conservation importance.

| Family | Species | Conservation status | Exotic | Growth form |
|---|---|---|---|---|
| Fabaceae | *Acacia xanthophloea* Benth. | | | tree |
| Fabaceae | *Acacia hebeclada* DC. | | | tree |
| Bombacaceae | *Adansonia digitata* L. | | | tree |
| Passifloraceae | *Adenia gummifera* (Harv.) Harms | | | liana |
| Fabaceae | *Aeschynomene cristata* Vatke | | | legume |
| Fabaceae | *Aeschynomene elaphroxylon* (Guill. & Perr.)Taub. | | | legume |
| Fabaceae | *Abrus precatorius* L. | | Asia | liana |
| Asteraceae | *Ageratum conyzoides* L. subsp. h*ustoniana* | | South America | forb |
| Asteraceae | *Ageratum houstoniana* Mill. subsp. *houstoniana* | | South America | forb |
| Fabaceae | *Albizia anthelmintica* Brongn. | | | tree |
| Amaranthaceae | *Alternanthera nodiflora* R. Br. | LC | Australia | aquatic herb |
| Amaranthaceae | *Alternanthera pungens* Kunth | | Australia | aquatic herb |
| Amaranthaceae | *Alternanthera sessilis* R. Br. | LC | South America | aquatic herb |
| Amaranthaceae | *Amaranthus hybridus* L. | | | aquatic herb |
| Amaranthaceae | *Amaranthus lividus* L. | | Americas | aquatic herb |
| Amaranthaceae | *Amaranthus spinosus* L. | | Americas | aquatic herb |
| Lythraceae | *Ammania erecta* Guill. & Perr. | | | aquatic herb |
| Lythraceae | *Ammania prieuriana* Guill. & Perr. | | | aquatic herb |
| Papaveraceae | *Argemone mexicana* L. | | South America | forb |
| Arthropteraceae | *Arthropteris monocarpa* (Cordem.) C. Chr. | | | fern |
| Asparagaceae | *Asparagus krebsianus* (Kunth) Jessop | | | shrub |
| Meliaceae | *Azadirachta indica* A. Juss. | | Asia | tree |
| Azollaceae | *Azolla filiculoides* Lam. | | South America | aquatic fern |
| Azollaceae | *Azolla nilotica* Decne. ex Mett. | LC | | aquatic fern |
| Azollaceae | *Azolla pinnata* R.Br. | LC | | aquatic fern |
| Amiaceae | *Basilicum polystachyon* L. | | Australia | forb |
| Asteraceae | *Bidens pillosa* L. | | Americas | forb |
| Acanthaceae | *Blepharis acanthodioides* Klotzsch | | | forb |
| Asteraceae | *Blumea viscosa* (Mill.) V.M.Badillo | | | forb |
| Nyctaginaceae | *Boerhavia coccinea* Mill. | | South America | forb |
| Nyctaginaceae | *Boerhavia diffusa* L. | | South America | forb |
| Palmae | *Borassus aethiopium* Mart. | | | palm |
| Euphorbiaceae | *Bridelia cathartica* Bertel. f. | | | tree |
| Capparaceae | *Cadaba kirkii* Oliver | | | shrub |
| Fabaceae | *Caesalpinnia bonduc* (L.) Roxb. | | Sri Lanka | shrub |
| Asclepiadaceae | *Calotropis procera* (Ait.) Ait. Fil | | | shrub |
| Capparaceae | *Capparis erythrocarpos* Isert | | | shrub |
| Capparaceae | *Capparis tomentosa* Lam. | | | shrub |
| Sapindaceae | *Cardiospermum halicacabum* L. | | | liana |
| Cyperaceae | *Carex cognata* Kunth. | LC | | sedge |
| Cyperaceae | *Carex mannii* E.A.Bruce | | | sedge |
| Amaranthaceae | *Celosia trygyna* L. | | | forb |
| Amaranthaceae | *Celosia argentea* L. | | | forb |

| Family | Species | Conservation status | Exotic | Growth form |
|---|---|---|---|---|
| Apiaceae | *Centella asiatica* (L.) Urb. | LC | Asia | forb |
| Amaranthaceae | *Centrostachys aquatica* (R.Br.) Baill. | LC | | aquatic herb |
| Ceratophyllaceae | *Ceratophyllum demersum* L. | LC | | aquatic herb |
| Pteridaceae | *Ceratopteris cornuta* (P. Beau) Lepr. | | | aquatic herb |
| Fabaceae | *Chamaecrista hirta* L. | | South America | forb |
| Chenopodiaceae | *Chenopodium ambrosioides* L. | | South America | forb |
| Menispermaceae | *Cissampelos mucronata* A. Rich. | | | forb |
| Vitaceae | *Cissus grisea* (Bak.) Planch | | | forb |
| Amnonaceae | *Cleistochlamys kirkii* (Benth.) Oliv. | | | tree |
| Combretaceae | *Combretum adenogonium* Steud. ex. A. Rich. | | | tree |
| Combretaceae | *Combretum microphyllum* Klotzsch | | | tree |
| Commelinaceae | *Commelina bengalensis* L. | | | forb |
| Commelinaceae | *Commelina diffusa* Burm.f. | LC | | forb |
| Bursenaceae | *Commiphora marlothii* Engl. | | | tree |
| Convolvulaceae | *Convolvus farinosus* Jacq. | | | forb |
| Asteraceae | *Conyza bonariensis* (L.) Cronquist | | South America | forb |
| Asteraceae | *Conyza pyrrhopappa* Sch.Bip. Ex A.Rich. | | | forb |
| Asteraceae | *Conyza stricta* Willd. | | | forb |
| Cucurbitaceae | *Corallocarpus bainesii* (Hook. fil.) A. Meeuse | | | tuber |
| Molluginaceae | *Corbichonia decumbens* (Forsk.) Exell | | | forb |
| Tiliaceae | *Corchorus olitorius* L. | | | forb |
| Boraginaceae | *Cordia abyssinica* R. Br. | | | tree |
| Fabaceae | *Cordyla africana* Lour. | | | tree |
| Asteraceae | *Crassocephalum rubens* (Jacq.) S. Moor. | | | forb |
| Fabaceae | *Crotaleria erecta* Steud. Ex. A. Rich. | | | tree |
| Euphorbiaceae | *Croton macrostachys* Hochst. Ex. A. Rich. | | | tree |
| Poaceae | *Cynodon aethiopicus* W.D. Clayton & Harlan | | | grass |
| Poaceae | *Cynodon dactylon* (L.) Pers. | | | grass |
| Poaceae | *Cynodon nlemfuensis* Vanderyst. | | | grass |
| Cyperaceae | *Cyperus alopecuroides* Rottb. | LC | | sedge |
| Cyperaceae | *Cyperus alternifolius* Kuk. | LC | | sedge |
| Cyperaceae | *Cyperus amabilis* Vahl | LC | | sedge |
| Cyperaceae | *Cyperus articulatus* L. | LC | | sedge |
| Cyperaceae | *Cyperus aterrimus* Hochst. ex Steud. | LC | | sedge |
| Cyperaceae | *Cyperus compressus* L. | LC | | sedge |
| Cyperaceae | *Cyperus cyperoides* (L.) Kuntze | C | | sedge |
| Cyperaceae | *Cyperus denudatus* L.f. | | | sedge |
| Cyperaceae | *Cyperus derreilema* Steud. | | | sedge |
| Cyperaceae | *Cyperus difformis* L. | LC | | sedge |
| Cyperaceae | *Cyperus digitatus* Roxb. | LC | | sedge |
| Cyperaceae | *Cyperus distans* L.f. | LC | | sedge |
| Cyperaceae | *Cyperus dives* Delile | | | sedge |
| Cyperaceae | *Cyperus dubius* Rottb. | LC | | sedge |
| Cyperaceae | *Cyperus exaltatus* Retz. | | | sedge |
| Cyperaceae | *Cyperus imbricatus* Retz. | LC | | sedge |
| Cyperaceae | *Cyperus lulvignatus* L. | | | sedge |
| Cyperaceae | *Cyperus macrostachyos* var. *tremulus* (Poir.) Lye | | | sedge |
| Cyperaceae | *Cyperus microbolbos* C.B.Clarke | DD | | sedge |
| Cyperaceae | *Cyperus nudicaulis* Poir. | | | sedge |
| Cyperaceae | *Cyperus papyrus* L. | LC | | sedge |
| Cyperaceae | *Cyperus pilosus* Vahl | LC | | sedge |
| Cyperaceae | *Cyperus polystachyos* (Rottb.) P.Beauv. | LC | | sedge |
| Cyperaceae | *Cyperus rotundus* L. | LC | | sedge |
| Cyperaceae | *Cyperus schimperianus* Steud. | LC | | sedge |
| Cyperaceae | Cyperus squarrosus L. | LC | | sedge |
| Cyperaceae | *Cyperus zollingerii* Steud. | | | sedge |

| Family | Species | Conservation status | Exotic | Growth form |
|---|---|---|---|---|
| Fabaceae | *Dalbergia lactea* Vatke | | | liana |
| Fabaceae | *Desmodium salicifolium* (Poir.) DC. | LC | | shrub |
| Asteraceae | *Dicrocephala integrifolia* (L. f.) Kuntze | | | forb |
| Poaceae | *Digitaria diagonalis* (Nees) Stapf | | | grass |
| Ebenceae | *Diospyros quiloensis* (Hiern) F.White | | | tree |
| Ebenceae | *Diospyros squarrosa* Klotzsch | | | tree |
| Poaceae | *Echinochloa haploclada* (Stapf) Stapf | | | grass |
| Poaceae | *Echinochloa pyramidalis* (Lam.) Hitchc. & Chase | LC | | grass |
| Asteraceae | *Eclipta prostrata* (L.) L. | DD | | forb |
| Pontederaceae | *Eichornia crassipes* (C.Mart.) Solms. | | South America | aquatic weed |
| Poaceae | *Eleusine indica* (L.) Gaertn. | LC | | grass |
| Poaceae | *Eragrostis racemosa* (Thunb.) Steud. | | | grass |
| Poaceae | *Eragrostis sphacetus* Rottb. | | | grass |
| Poaceae | *Eragrostis welwitschii* Rendle | | | grass |
| Euphorbiaceae | *Euphorbia depauperata* Hochst. ex. A.Rich. | | | shrub |
| Fabaceae | *Faidherbia albida* (Del.) A. Chev. | | | tree |
| Moraceae | *Ficus caprefiolia* Delile. | | | tree |
| Moraceae | *Ficus exasperata* Vahl | | | tree |
| Moraceae | *Ficus sycamorus* L. | | | tree |
| Cyperaceae | *Fimbristylis dephylla* Vahl. | | | sedge |
| Cyperaceae | *Fimbristylus exalis* (Kunth) Roem. & Schultz. | | | sedge |
| Cyperaceae | *Fimbristylus hispidula* Kunth. | | | sedge |
| Cyperaceae | *Fuirena stricta* Steud. | | | sedge |
| Cyperaceae | *Fuirena umbellata* Rottb. | LC | | sedge |
| Asteraceae | *Galinsoga parviflora* Ca. V | | South America | forb |
| Aizoaceae | *Gisekia pharnacoides* L. | | | forb |
| Molluginaceae | *Glinus leptocarpa* (Nutt.) Harm. | | | forb |
| Molluginaceae | *Glinus lotoides* L. | | | forb |
| Molluginaceae | *Glinus oppositifolius* (L.) A. DC. | | | forb |
| Lamiaceae | *Gmelina arborea* Roxb. | | Asia | forb |
| Asteraceae | *Gnaphalium pennsylvanicum* Wild. | | | forb |
| Asteraceae | *Gnaphalium polycaulon* Pers. | | | forb |
| Asclepiadaceae | *Gomphocarpus fruticosus* (L.) Aiton. f. | | | shrub |
| Asteraceae | *Grangea maderaspatana* (L.) Poir. | LC | Asia | shrub |
| Celastraceae | *Gymnosporia senegalensis* (Lam.) Loes. | | | tree |
| Boraginaceae | *Heliotropium indicum* L. | | Asia | forb |
| Boraginaceae | *Heliotropium valifolium* Forsk. | | Asia | forb |
| Malvaceae | *Hibiscus diversifolius* Jacq. | | | shrub |
| Apocynaceae | *Holarrhena pubescens* (Buch.-Hamm.) Wall. Ex G.Don | LC | Asia | shrub |
| Apiaceae | *Hydrocotyle mannii* Hook. fil. | | | forb |
| Hydrostachydaceae | *Hydrostachys polymorpha* Klotzsch | | | forb |
| Fabaceae | *Indigofera antunesiana* Harms | | | forb |
| Fabaceae | *Indigofera emarginella* A.Rich. | | | forb |
| Fabaceae | *Indigofera hirsuta* L. | | | forb |
| Fabaceae | *Indigofera tinctoria* L. | | | forb |
| Convolvulaceae | *Ipmoea aquatica* Forssk. | | | liana |
| Convolvulaceae | *Ipmoea coptica* (L.) Roth. Ex. Roem & Schultz | | | liana |
| Convolvulaceae | *Ipmoea obscurra* (L.) Ker-Gauvul | | | liana |
| Convolvulaceae | *Ipmoea pes-tigridis* L. | | | liana |
| Bignoniaceae | *Kigelia africana* (Lam.) Benth. | | | tree |
| Cyperaceae | *Kyllinga alba* Nees | | | sedge |
| Cucurbitaceae | *Lagenaria siceraria* (Molina) Standl. | | | gourd |
| Asteraceae | *Launaea cornuta* (Hochst. Ex Oliv. & Hiern) C.Jeffrey | | | vegetable |
| Poaceae | *Leersia hexandra* Sw. | | | grass |
| Lemnaceae | *Lemna aequinoctiale* Weber. | | | aquatic herb |

| Family | Species | Conservation status | Exotic | Growth form |
|---|---|---|---|---|
| Lamiceae | *Leonoitis nepetifolia* (L.) R. Br. | | | shrub |
| Alismataceae | *Limnophyton angolense* Buchenau | | | aquatic herb |
| Scrophulariaceae | *Limnophilla indica* (L.) Druce. | | Asia | aquatic herb |
| Scrophulariaceae | *Limosella africana* Gluck | | | aquatic herb |
| Scrophulariaceae | *Lindernia nummulariifolia* (D. Don.) Wettst. | | | aquatic herb |
| Onagraceae | *Ludwiggia abyssinica* A. Rich. | | | aquatic herb |
| Onagraceae | *Ludwiggia erecta* (L.) Hara | | | aquatic herb |
| Onagraceae | *Ludwiggia leptocarpa* (Nutt.) Harm. | | | aquatic herb |
| Onagraceae | *Ludwiggia octovalvis* (C.Jacq.) Raven. | | | aquatic herb |
| Onagraceae | *Ludwiggia perennis* L. | | | aquatic herb |
| Onagraceae | *Ludwiggia stolonifera* (Guill. & Perr.) Pitt.Raven. | | | aquatic herb |
| Cucurbitaceae | *Luffa cylindrica* (L.) Roem. | | | gourd |
| Moraceae | *Maclura africana* (Bur.) Corner | | | tree |
| Capparaceae | *Maerua angolensis* DC. | | | vegetable |
| Capparaceae | *Maerua kirkii* (Oliv.) F. White. | | | vegetable |
| Anacardiaceae | *Mangifera indica* L. | DD | | tree |
| Cyperaceae | *Mariscus hemisphaericus* (Boeckeler) C.B.Clarke. | | | sedge |
| Bignoniaceae | *Markannia obtusifolia* (Bak.) Sprague. | | Asia | tree |
| Asteraceae | *Melanthera scandens* (Schumach. & Thonn.) Roberty | | | liane |
| Asteraceae | *Mikania cordata* (Burm.f.) B.L.Rob. | | South America | liane |
| Fabaceae | *Mimosa pigra* L. | | South America | shrub |
| Scrophulariaceae | *Mimulus gracilis* R.Br. | LC | Asia | shrub |
| Cucurbitaceae | *Momordica cardiospermoides* Kl. | | | gourd |
| Cucurbitaceae | *Momordica foetida* Schum. | | | gourd |
| Annonaceae | *Monanthotaxis buchananii* (Engl.) Verdc. | | | liana |
| Asteraceae | *Mucuna coriaceae* Bak. subsp. *coriaceae* | | | shrub |
| Musaceae | *Musa paradisiaca* L. | | | shrub |
| Haloragaceae | *Myriophyllum spicatum* L. | LC | | aquatic herb |
| Najadaceae | *Najas pectinata* (Parl.) Magnus | LC | | aquatic herb |
| Asteraceae | *Neojeffreya decurrens* (L.) Cabrera | | | forb |
| Fabaceae | *Neptunia oleracea* Lour. | LC | South America | forb |
| Lythraceae | *Nesaea cordata* Hiern | | | forb |
| Lythraceae | *Nesaea radicans* Guill. & Perr. | | | forb |
| Asteraceae | *Nidorella auriculata* DC. | | | forb |
| Asteraceae | *Nidorella resedifolia* DC. | | | forb |
| Nymphaceae | *Nymphaea caerulla* Savigny. | | | aquatic macrophyte |
| Nymphaceae | *Nymphaea lotus* L. | | | aquatic macrophyte |
| Nymphaceae | *Nymphaea nouchali* Burm.f. | LC | | aquatic macrophyte |
| Menyanthaceae | *Nymphoides brevipedicellata* (Vatke) A.Raynal | LC | | aquatic macrophyte |
| Menyanthaceae | *Nymphoides indica* (L.) Kuntze | LC | | aquatic macrophyte |
| Lamiceae | *Ocimum canum* Sims | | | forb |
| Hydrocaritaceae | *Ottelia exserta* (Ridl.) Dandy | DD | | aquatic macrophyte |
| Commelinaceae | *Oxycaryum cubensis* Poepp & Kunth | | | sedge |
| Poaceae | *Panicum ecklonii* Nees | | | grass |
| Poaceae | *Panicum maximum* Jacq. | | | grass |
| Poaceae | *Panicum monticolum* Hook. f. | | | grass |
| Fabaceae | *Parkinsonia aculata* Plum. Ex L. | | USA | shrub |
| Poaceae | *Paspalidium germinatum* (Forssk.) Stapf. | | | aquatic grass |
| Poaceae | *Paspalum scrobiculatum* L. | LC | | grass |
| Poaceae | *Pennisetum purpureum* Schumach. | | | grass |

| Family | Species | Conservation status | Exotic | Growth form |
|---|---|---|---|---|
| Polygonaceae | *Persicaria decipiens* (R. Br.) K. L. Wilson. | | | aquatic perennial |
| Polygonaceae | *Persicaria senegalensis* (Meisn.) Sojak | LC | | aquatic perennial |
| Fabaceae | *Philenoptera violaceae* (Klotzsch.) Schrire. | | | tree |
| Poaceae | *Phragmites australis* Cav. (Steud). | LC | | reed |
| Poaceae | *Phragmites mauritianus* Kunth | | | reed |
| Verbenaceae | *Phylla nodiflora* (L.) Greene. | | | rhizomatous perennial |
| Araceae | *Pistia stratiotes* L. | | South America | aqautic weed |
| Asteraceae | *Pluchea discorides* (L.) DC. | | | shrub |
| Podostemaceae | *Podostemon aquatica* (C.H. Wright) Press. | | | aquatic forb |
| Polygalaceae | *Polygala virgata* Thunb. | | | shrub |
| Portulacaceae | *Portulaca oleracea* L. | | Asia | forb |
| Potamogetonaceae | *Potamogeton americanus* var. *thunbergii* (Cham. & Schltdl.) | | | aquatic perennial |
| Fabaceae | *Prosopis grandulosa* Torrey | | USA | tree |
| Asteraceae | *Pseudognaphalium luteo-album* (L.) H & B. | | Europe | forb |
| Asteraceae | *Pseudognaphalium oligandrum* (DC.) Hilliard & B.L.Burtt | | Europe | forb |
| Fabaceae | *Psophocarpus lancifolius* Harms. | | | liana |
| Cyperaceae | *Pycreus flavescens* (L.) P.Beauv. Ex. Rchb. | LC | | sedge |
| Fabaceae | *Rhynchosia minima* (L.) DC. | LC | | shrub |
| Euphorbiaceae | *Ricinus communis* L. | | | shrub |
| Crucifera | *Rorippa micrantha* (Roth) Jonsell | | | forb |
| Poaceae | *Rumex abyssinica* Jacq. | | | forb |
| Polygonaceae | *Rumex begnaertii* De Wild. | | | forb |
| Polygonaceae | *Sacciolepis africana* C. E. Hubb. ex. Snodon. | | | grass |
| Poaceae | *Sacciolepsis indica* L. | | | grass |
| Poaceae | *Salvinia hastata* Desv. | | | aquatic fern |
| Salviniaceae | *Salvinia molesta* Mitch. | | South America | aquatic fern |
| Salviniaceae | *Schoenoplectus articulata* (L.) Palla | | | sedge |
| Cyperaceae | *Schoenoplectus corymbosus* (Roth ex Roem. & Schult.) J.Raynal | LC | | sedge |
| Cyperaceae | *Schoenoplectus subulatus* (Vahl) Lye | | | sedge |
| Fabaceae | *Senna alata* (L.) Roxb. | | | shrub |
| Fabaceae | *Senna occidentalis* (L.)Link. | | | shrub |
| Fabaceae | *Senna siamea* (Lam.)H.S.Irwin & Barneby | | | shrub |
| Fabaceae | *Sesbania bispinosa* (Jacq.) W.Wight | LC | | tree |
| Fabaceae | *Sesbania hirsuta* (L.) Irwin & Barnaby. | | | tree |
| Fabaceae | *Sesbania leptocarpa* DC. | | | tree |
| Fabaceae | *Sesbania macrantha* E.Phillips & Hutch. | | | tree |
| Fabaceae | *Sesbania sesban* (L.)Merr. | | | tree |
| Fabaceae | *Sesbania tetraptera* Baker | | | tree |
| Poaceae | *Setaria sphacelata* (Schumach.) Stapf. & C.E.Hubb. Ex Moss | | | grass |
| Euphorbiaceae | *Shirakiopsis elliptica* (Hochst.) Esser | | | tree |
| Malvaceae | *Sida acuta* Burm. fil. | | | shrub |
| Asteraceae | *Sigesbeckia orientalis* L. | | | forb |
| Solanceae | *Solanum nigrum* L. | | Europe | forb |
| Poaceae | *Sorghum arundinaceaum* (Desr.) Stapf. | | | grass |
| Asteraceae | *Sphaeranthus randii* S. Moore | | | forb |
| Asteraceae | *Sphaeranthus angolensis* O. Hoffm. | | | forb |
| Asteraceae | *Sphaeranthus peduncularis* sensu Volkens non DC. | | | forb |
| Asteraceae | *Spilanthes mauritiana* (a.Rich. ex. Pers.) DC. | | | forb |
| Poaceae | *Sporobolus consimilis* Fresen. | LC | | grass |
| Poaceae | *Sporobolus pyramidalis* P.Beauv. | | | grass |
| Sterculiaceae | *Sterculia africana* (Lour.) Fiori | | | tree |
| Colvolvulaceae | *Stictocardia laxiflora* (Bak) Hall. fil. | | | forb |
| Asteraceae | *Synedrella nodiflora* (L.) Gaertn. | | Asia | forb |
| Apocynaceae | *Tabernaemontana elegans* Stapf | | | tree |

| Family | Species | Conservation status | Exotic | Growth form |
|---|---|---|---|---|
| Asclepiadaceae | *Tacazzea apiculata* Oliv. | | | liana |
| Thelypteridaceae | *Thelypteris confluens* (Thunb.) Morton. | | | rhizomatous perennial |
| Thelypteridaceae | *Thelypteris hispidula* (Decne.) C.F.Reed | | | rhizomatous perennial |
| Thelypteridaceae | *Thelypteris totta* (Thunb.) Schelpe | | | rhizomatous perennial |
| Capparaceae | *Thilachium africanum* Lour. | | | shrub |
| Acanthaceae | *Thunbergia alata* Boj. ex Sims | | | forb |
| Trapaceae | *Trapa natans* L. | LC | | aquatic macrophyte |
| Aizoaceae | *Trianthema portulastrum* L. | | | forb |
| Meliaceae | *Trichelia emetica* Vahl. | | | tree |
| Boraginaceae | *Trichodesma zeylamicum* (Burm.f.) R.Br. | | Phillipines | tree |
| Asteraceae | *Tridax procumbens* L. | | South America | forb |
| Colvolvulaceae | *Turbina shirensis* (Oliv.) A. Meeuse | | | liana |
| Typhaceae | *Typha domingensis* Pers. | LC | | reed |
| Poaceae | *Urochloa mosambicensis* (Hoek.) Dandy. | | | grass |
| Asteraceae | *Vernonia chloropappa* Baker | | | forb |
| Asteraceae | *Vernonia glabra* Koord. & Valeton | | | forb |
| Asteraceae | *Veronia paskenna* Vatke & Hildebr. | | | forb |
| Fabaceae | *Vigna luteola* (Jacq.) Benth. | | | forb |
| Fabaceae | *Vigna vexillata* (L.)A.Rich. | | | forb |
| Poaceae | *Vossia cuspidata* (Roxb.) Griff. | | | grass |
| Asteraceae | *Xanthium strumarium* L. | | USA | forb |
| Fabaceae | *Xanthocercis zambesiaca* (Baker) Dumaz-le-Grand | | | tree |
| Aizoaceae | *Zaleya pentandra* (L.) C. Jeffrey | | | forb |
| Rutaceae | *Zanthoxylum chalybeum* Engl. | | | tree |
| Rhamnaceae | *Ziziphus mauritianus* Kunth. | | | tree |

# Appendix 2: Aquatic Inverebrates

## A: Site Descriptions

**A list of sample sites in the study area, including sample dates and locations.**

| Sample Site (Area name) | Site no. | Date | River | Latitude (S) | Longitude (E) | Elevation (m a.m.s.l.) |
|---|---|---|---|---|---|---|
| North-western Elephant Marshes | NEM-01 | 19/01/2016 | Shire | 16°16′16.64″ | 34°55′21.79″ | 60 - 80 |
| | NEM-02 | | | 16°16′16.75″ | 34°55′26.61″ | 60 - 80 |
| | NEM-03 | | | 16°17′32.64″ | 34°55′32.08″ | 60 - 80 |
| | NEM-04 | | | 16°17′42.79″ | 34°56′37.42″ | 60 - 80 |
| | NEM-05 | | | 16°17′50.82″ | 34°56′46.86″ | 60 - 80 |
| | NEM-06 | | | 16°18′18.28″ | 34°57′13.96″ | 60 - 80 |
| Nyala Park | NP-01 | 17/01/2016 | Endoheric Pan | 16°10′22.22″ | 34°51′50.79″ | 60 - 80 |
| | NP-02 | 18/01/2016 | Dam-channel | 16°10′14.66″ | 34°51′41.11″ | 60 - 80 |
| | NP-03 | 18/01/2016 | Channel | 16°10′11.71″ | 34°51′58.89″ | 60 - 80 |
| West flowing tributaries | RV-01 | 19/01/2016 | Mwamphanzi | 16°02′41.17″ | 34°51′51.84″ | 100 - 120 |
| | RV-02 | 18/01/2016 | Nkhuzi | 16°04′43.49″ | 34°52′50.59″ | 80 - 100 |
| | RV-03 | 18/01/2016 | Maperera | 16°05′48.58″ | 34°54′42.04″ | 80 - 100 |
| | RV-04 | 18/01/2016 | Limphangwi | 16°09′14.90″ | 34°58′17.86″ | 80 - 100 |
| South-western Elephant Marshes | SEM-01 | 20/01/2016 | Shire | 16°27′31.03″ | 35°03′44.13″ | 40 - 60 |
| | SEM-02 | | | 16°27′47.98″ | 35°03′56.41″ | 40 - 60 |
| | SEM-03 | | | 16°27′50.07″ | 35°04′12.39″ | 40 - 60 |
| | SEM-04 | | | 16°27′59.79″ | 35°04′28.99″ | 40 - 60 |
| | SEM-05 | | | 16°28′43.71″ | 35°04′42.92″ | 40 - 60 |
| | SEM-06 | | | 16°29′00.95″ | 35°04′37.99″ | 40 - 60 |
| | SEM-07 | | | 16°29′03.94″ | 35°04′39.79″ | 40 - 60 |
| | SEM-08 | | | 16°29′04.09″ | 35°04′42.63″ | 40 - 60 |
| | SEM-09 | | | 16°31′03.14″ | 35°06′48.56″ | 40 - 60 |
| | SEM-10 | | | 16°32′25.65″ | 35°07′55.30″ | 40 - 60 |
| | SEM-11 | | | 16°33′49.30″ | 35°07′41.30″ | 40 - 60 |
| Western Clear-water lake | WEM-01 | 21/01/2016 | | 16°31′23.59″ | 35°04′51.34″ | 40 - 60 |
| | WEM-02 | | | 16°31′26.72″ | 35°04′55.77″ | 40 - 60 |
| | WEM-03 | | | 16°31′32.69″ | 35°05′04.34″ | 40 - 60 |
| | WEM-04 | | | 16°31′34.46″ | 35°05′01.57″ | 40 - 60 |
| | WEM-05 | | | 16°31′37.12″ | 35°04′56.24″ | 40 - 60 |
| | WEM-06 | | | 16°31′45.08″ | 35°04′41.23″ | 40 - 60 |
| | WEM-07 | | | 16°31′42.70″ | 35°04′05.16″ | 40 - 60 |
| | WEM-08 | | | 16°31′51.78″ | 35°04′09.01″ | 40 - 60 |
| | WEM-09 | | | 16°32′01.14″ | 35°04′19.56″ | 40 - 60 |

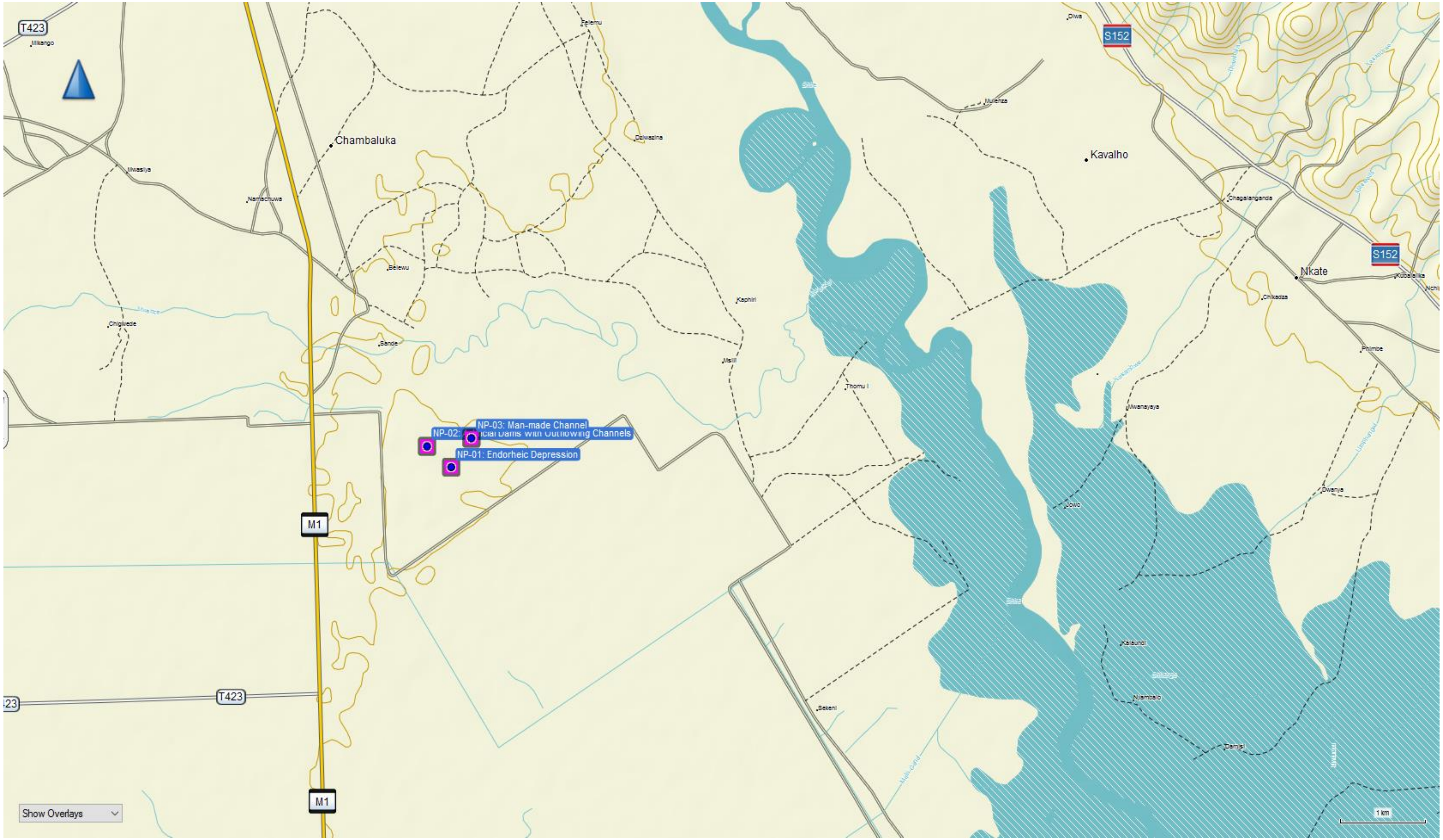
### Site-Catchment Ratings

The table below provides the ratings used when describing the presence of aquatic type, hydraulic type, biotopes, vegetation, substrates, land-use and habitat integrity.

| Rating (0-6) | |
|---|---|
| **0** | **Absent** |
| **1** | **Rare (<5%)** |
| **2** | **Sparse 6-25%)** |
| **3** | **Common (26-50%)** |
| **4** | **Abundant (51-75%)** |
| **5** | **Predominant (76-95%)** |
| **6** | **Near Entire (>95%)** |

## Site 1. Nyala Park

Three sites were sampled in Nyala Park, a recreational park for the staff of Illovo Sugarmill, with semi-natural terrestrial vegetation. Due to heavy rain, access to the road network was limited. One endorheic depression was visited (visual observations only), and the impoundments and man-made channel were sampled. An insert of a topo-cadastral map indicating the location of the three sampling locations follows. (Copied from Garmin BaseCamp Version 4.4.7, Garmap Southern Africa TOPO 2013 PRO).




**Topo-cadastral map indicating the location of the three sampling locations at Nyala Park**

### *SITE NP-01: Endorheic Depression*

The below photo shows the habitat of the site.

**View of the endorheic depression facing north-west (17 January 2016)**

### Site Information

Relevant site location details.

| | | | |
|---|---|---|---|
| **Site Code:** | NP-01 | **Date:** | 17 January 2016 |
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 561: Lower Zambezi | |
| **Latitude:** | -16.17284° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 34.86411° E | **Elevation:** | 60-80 m a.m.s.l. |

A summary of site characteristics, including hydrogeomorphic unit, biotopes, vegetation and water quality.

| **Hydro-geomorphic Unit** | | | |
|---|---|---|---|
| **Unit** | **Type** | **Landform** | **In-/Outflow** |
| Wetland | Depression | Endorheic | Inflow |

| Biotopes | | | | | |
|---|---|---|---|---|---|
| **Hydraulic** | | | **Substrates** | | |
| **Inundation** | Permanent | | **Organic** | Leaves/Detritus | **1** |
| | Seasonal | **6** | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | **6** |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | |
| | Riffle | | | Sand – Fine | |
| | Run | | | Sand - Coarse | |
| | Glide | | **Rocky** | Gravel – F (2-8) | |
| | Pool | **6** | | Gravel – M (8-16) | |
| | Backwater | | | Gravel - C (16–64) | |
| **Artificial** | Canal | | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| **Cover** | | **Water** | **Marginal** | **Riparian** |
| **Aquatic** | Floating | | | |
| | Submerged | | | |
| | Emergent | | | |
| **Herbaceous** | Bare | **6** | **6** | **2** |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | | | **1** |
| | Herbs | | | |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | | **3** |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | **4** |
| | Plantation | | | |

| Water Quality[10] | | | | | |
|---|---|---|---|---|---|
| **Salinity** | Fresh (<500 mS/m) | | **Temperature** | °C | |
| | Brackish (500-3000 mS/m) | | **Dissolved Oxygen** | mg/ℓ | |
| | Saline (3000-8000 mS/m) | | | % | |
| | Hypersaline (>8000 mS/m) | | **Conductivity** | ∓S/cm | |
| **pH** | Acidic (<6) | | **Water Clarity** | cm | |
| | Circum-neutral (6-8) | | | | |
| | Alkaline (>8) | | | | |

### Catchment Land-use

The below is a summary of catchment land-use likely to affect surface waters.

| **Landuse** | **(0-6)** |
|---|---|
| Conservation/Wilderness | **6** |
| Livestock - Grazing | **3** |
| Mining - Underground | |
| Forestry | |
| Recreation | |
| Cultivation - Dryland | |
| Cultivation - Irrigated | |
| Residential - Rural | |
| Residential - Urban | |
| Commercial | |
| Industrial - Light | |
| Industrial - Heavy | |
| Livestock - Feedlots | |
| Mining - Open | |
| Other | |

[10] In situ water quality variables were not measure. The sampling equipment only arrived a day later from the airport.

**Catchment Disturbance**

The below is a summary of catchment disturbances which are rated on a scale from natural to critical.

| | ***Natural*** | | | | | ***Critical*** |
|---|---|---|---|---|---|---|
| **Parameter** | **Zero** | **VL** | **Low** | **Mod** | **High** | **VH** |
| Catchment | x | | | | | |
| Roads/Bridges/Culverts | | | x | | | |
| Impoundments/Weirs | x | | | | | |
| Livestock | | | x | | | |
| Fire | x | | | | | |
| Sewage Fungus | x | | | | | |
| Algae - Benthic | x | | | | | |
| Algae - Planktonic | x | | | | | |
| Macrophytes | x | | | | | |
| Hydrocarbons | x | | | | | |
| Turbidity | | | | | | x |
| Colour | | | | | | x |
| Odour | | | | x | | |
| Temperature | | | | | | |
| Foam | x | | | | | |
| pH | | | | | | |
| Other | | | | | | |

***SITE NP-02: Artificial Dams with Outflowing Channels***

Habitat photos of (a) the dam fed with pumped water and groundwater recharge and (b) the channel draining from the dam.

**(a) View, facing south-south west, of and artificially reservoir fed by groundwater (17 January 2016).**

**(b) View of artificially reservoir NNE channel outlet, facing downstream (17 January 2016).**

**View of the off-channel dam located on the eastern side of the outlet channel and north-north eastern side of the artificial reservoir (17 January 2016).**

**Site Information**

Relevant site location details.

| Site Code: | NP-02 | Date: | 17 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 561: Lower Zambezi | |
| **Latitude:** | -16.17074° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 34.86142° E | **Elevation:** | 60-80 m a.m.s.l. |

| Hydro-geomorphic Unit | | | |
|---|---|---|---|
| **Unit** | **Type** | **Landform** | **In-/Outflow** |
| Artificial | Dam-Channel | n/a | In-/Outflow |

| Biotopes | | | | | |
|---|---|---|---|---|---|
| **Hydraulic** | | | **Substrates** | | |
| **Inundation** | Permanent | **6** | **Organic** | Leaves/Detritus | **3** |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | **5** |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | **2** |
| | Riffle | | | Sand – Fine | |
| | Run | **3** | | Sand - Coarse | |
| | Glide | | **Rocky** | Gravel – F (2-8) | |
| | Pool | **4** | | Gravel – M (8-16) | |
| | Backwater | | | Gravel - C (16–64) | |
| **Artificial** | Canal | **3** | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | **4** | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| **Cover** | | **Water** | **Marginal** | **Riparian** |
| **Aquatic** | Floating | **6** | **6** | |
| | Submerged | **2** | **3** | |
| | Emergent | **2** | **4** | |
| **Herbaceous** | Bare | | | |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | **1** | **3** | **2** |
| | Herbs | **1** | **2** | **3** |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | **1** | **1** | |
| **Shrubs** | Shrubs | | **2** | **3** |
| | Thicket | | **4** | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | **4** | **4** |
| | Plantation | | | |

| Water Quality[11] | | | | | |
|---|---|---|---|---|---|
| **Salinity** | Fresh (<500 mS/m) | | **Temperature** | °C | |
| | Brackish (500-3000 mS/m) | | **Dissolved Oxygen** | mg/ℓ | |
| | Saline (3000-8000 mS/m) | | | % | |
| | Hypersaline (>8000 mS/m) | | **Conductivity** | ∓S/cm | |
| **pH** | Acidic (<6) | | **Water Clarity** | cm | |
| | Circum-neutral (6-8) | | | | |
| | Alkaline (>8) | | | | |

[11] In situ water quality variables were not measure. The sampling equipment only arrived a day later from the airport.

**Catchment Land-use**

A summary of catchment land-use likely to affect surface waters.

| **Land-use** | **(0-6)** |
|---|---|
| Conservation/Wilderness | 6 |
| Livestock - Grazing | 3 |
| Mining - Underground | |
| Forestry | |
| Recreation | 2 |
| Cultivation - Dryland | |
| Cultivation - Irrigated | |
| Residential - Rural | |
| Residential - Urban | |
| Commercial | |
| Industrial - Light | |
| Industrial - Heavy | |
| Livestock - Feedlots | |
| Mining - Open | |
| Other | |

**Catchment Disturbance**

A summary of catchment disturbances rated from natural to critical.

| | ***Natural*** | | | | | ***Critical*** |
|---|---|---|---|---|---|---|
| **Parameter** | **Zero** | **VL** | **Low** | **Mod** | **High** | **VH** |
| Catchment | x | | | | | |
| Roads/Bridges/Culverts | | | x | | | |
| Impoundments/Weirs | | | | | x | |
| Livestock | | | x | | | |
| Fire | x | | | | | |
| Sewage Fungus | x | | | | | |
| Algae - Benthic | | | x | | | |
| Algae - Planktonic | | | | x | | |
| Macrophytes | | | | | | x |
| Hydrocarbons | x | | | | | |
| Turbidity | | | | x | | |
| Colour | | | | x | | |
| Odour | | | | x | | |
| Temperature | | | | | | |
| Foam | x | | | | | |
| pH | | | | | | |
| Other | | | | | | |

***SITE NP-03: Man-made Channel***

Habitat photos of the man-made channel downstream from the picnic site (NP-02).

**View, facing west, of the artificially channel and bridge (17 January 2016).**

**View, facing east, of the artificially channel and bridge (17 January 2016).**

**Site Information**

Relevant site location details.

| | | | |
|---|---|---|---|
| **Site Code:** | NP-03 | **Date:** | 18 January 2016 |
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 561: Lower Zambezi | |
| **Latitude:** | -16.16992° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 34.86636° E | **Elevation:** | 60-80 m a.m.s.l. |

| **Hydro-geomorphic Unit** | | | |
|---|---|---|---|
| **Unit** | **Type** | **Landform** | **In-/Outflow** |
| Artificial | Channel | n/a | In-/Outflow |

| **Biotopes** | | | | | |
|---|---|---|---|---|---|
| **Hydraulic** | | | **Substrates** | | |
| **Inundation** | Permanent | **6** | **Organic** | Leaves/Detritus | **2** |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | **5** |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | **2** |
| | Riffle | | | Sand – Fine | |
| | Run | **5** | | Sand - Coarse | |
| | Glide | | **Rocky** | Gravel – F (2-8) | |
| | Pool | **1** | | Gravel – M (8-16) | |
| | Backwater | | | Gravel - C (16–64) | |
| **Artificial** | Canal | **6** | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | **2** | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| **Cover** | | **Water** | **Marginal** | **Riparian** |
| **Aquatic** | Floating | | | |
| | Submerged | 1 | | |
| | Emergent | 5 | 3 | |
| **Herbaceous** | Bare | | 3 | |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | | 2 | 3 |
| | Herbs | | 2 | 3 |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | 2 | 3 |
| | Thicket | | | 4 |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | 4 |
| | Plantation | | | |

| Water Quality | | | | | |
|---|---|---|---|---|---|
| **Salinity** | Fresh (<500 mS/m) | **x** | **Temperature** | °C | **26.4** |
| | Brackish (500-3000 mS/m) | | **Dissolved Oxygen** | mg/ℓ | |
| | Saline (3000-8000 mS/m) | | | % | |
| | Hypersaline (>8000 mS/m) | | **Conductivity** | ∓S/cm | **876** |
| **pH** | Acidic (<6) | | **Water Clarity** | cm | **>120** |
| | Circum-neutral (6-8) | **7.6** | | | |
| | Alkaline (>8) | | | | |

**Catchment Land-use**

A summary of catchment land-use likely to affect surface waters.

| **Land-use** | **(0-6)** |
|---|---|
| Conservation/Wilderness | 6 |
| Livestock - Grazing | 3 |
| Mining - Underground | |
| Forestry | |
| Recreation | |
| Cultivation - Dryland | |
| Cultivation - Irrigated | |
| Residential - Rural | |
| Residential - Urban | |
| Commercial | |
| Industrial - Light | |
| Industrial - Heavy | |
| Livestock - Feedlots | |
| Mining - Open | |
| Other | |

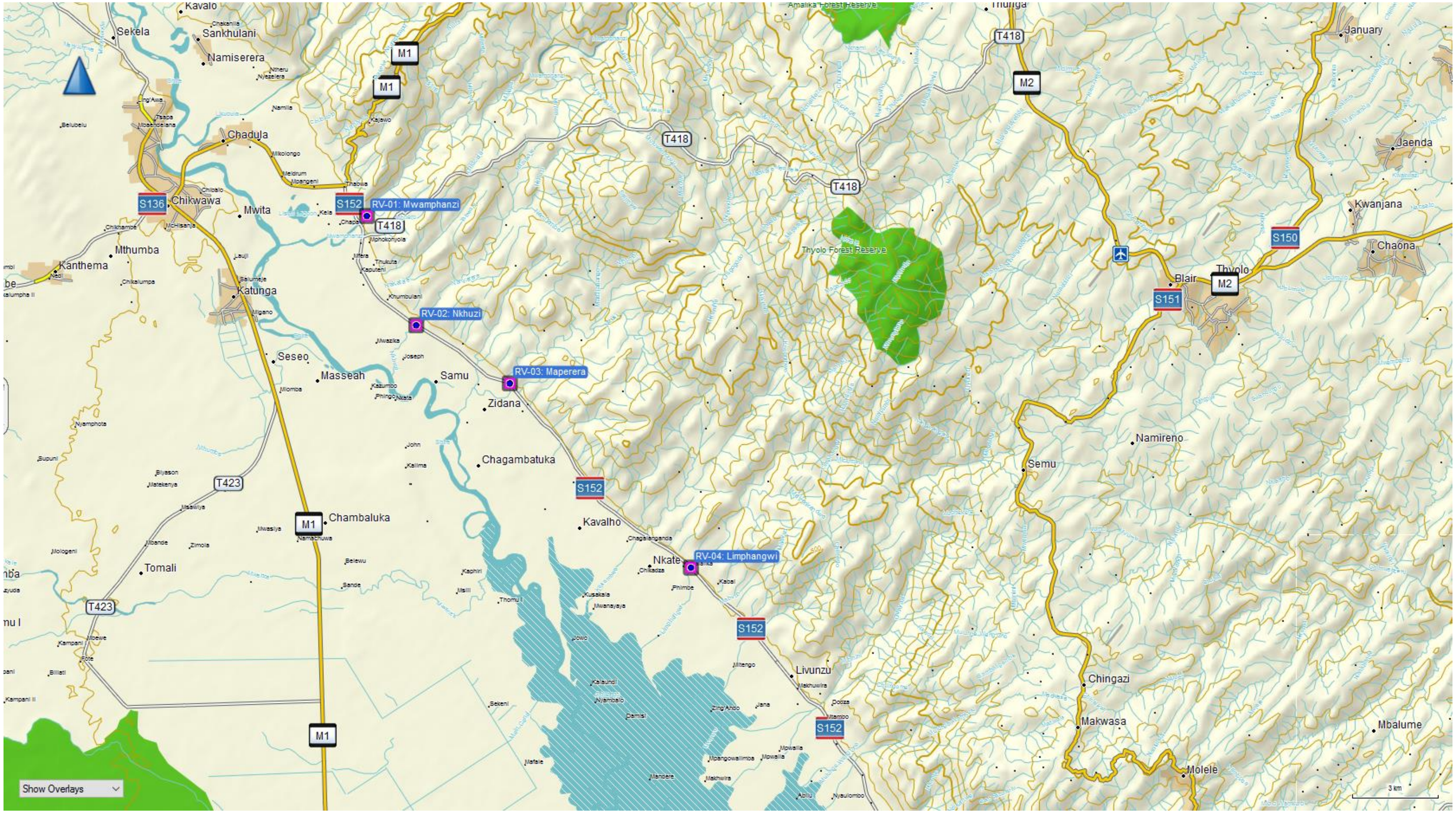
**Catchment Disturbance**

A summary of catchment disturbances rated from natural to critical.

| | ***Natural*** | | | | | ***Critical*** |
|---|---|---|---|---|---|---|
| **Parameter** | **Zero** | **VL** | **Low** | **Mod** | **High** | **VH** |
| Catchment | | | | x | | |
| Roads/Bridges/Culverts | | | x | | | |
| Impoundments/Weirs | | | | | x | |
| Livestock | | | x | | | |
| Fire | x | | | | | |
| Sewage Fungus | x | | | | | |
| Algae - Benthic | | x | | | | |
| Algae - Planktonic | | | | x | | |
| Macrophytes | | | | x | | |
| Hydrocarbons | x | | | | | |
| Turbidity | | x | | | | |
| Colour | | | x | | | |
| Odour | | | x | | | |
| Temperature | | | | x | | |
| Foam | x | | | | | |
| pH | x | | | | | |
| Other | | | | | | |

## Site 2. West-flowing tributaries

Four tributaries of the Shire River were sampled, numbered RV-01 from up- to RV-04 downstream. An insert of a topo-cadastral map roughly indicating the location of site locations is shown below (Copied from Garmin BaseCamp Version 4.4.7, Garmap Southern Africa TOPO 2013 PRO).




**Topo-cadastral map roughly indicating the location of site locations for Site 2: West flowing rivers**

***SITE RV-01: Mwamphanzi River***

Habitat photos of the Mwamphanzi River.

**Up- and downstream views of the Mwamphanzi River (19 January 2016). The left photograph is facing upstream and the right photo downstream towards the S152 bridge in the background.**

**Site Information**

Relevant site location details.

| **Site Code:** | RV-04 | **Date:** | 19 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.04477° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 34.86440° E | **Elevation:** | 100-120 m a.s.l. |

| Hydro-geomorphic Unit | | |
|---|---|---|
| **Unit** | **Type** | **Landform** |
| River | Upper Foothill | Active Channel/Riparian Zone |

| Biotopes | | | | | |
|---|---|---|---|---|---|
| **Hydraulic** | | | **Substrates** | | |
| **Inundation** | Permanent | **x** | **Organic** | Leaves/Detritus | **1** |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | **2** |
| | Cascade | | | Loam | |
| | Rapid | **1** | | Silt | **3** |
| | Riffle | **3** | | Sand – Fine | **5** |
| | Run | **4** | | Sand - Coarse | **4** |
| | Glide | **4** | **Rocky** | Gravel – F (2-8) | **4** |
| | Pool | **3** | | Gravel – M (8-16) | **3** |
| | Backwater | **2** | | Gravel - C (16–64) | **3** |
| **Artificial** | Canal | | | Cobble – Small (64-128) | **3** |
| | Dam (in-channel) | | | Cobble – Large (128-250) | **2** |
| | Dam (off-channel) | | | Boulder – Small (250-500) | **1** |
| | Excavation | | | Boulder – Med (500-1000) | **1** |
| | Salt Works | | | Boulder – Large (1000-4000) | **2** |
| | Pond (e.g. WWTW) | | | Bedrock | **1** |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| **Cover** | | **Water** | **Marginal** | **Riparian** |
| **Aquatic** | Floating | | | |
| | Submerged | | | |
| | Emergent | 1 | | |
| **Herbaceous** | Bare | | 3 | 2 |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | | 1 | 2 |
| | Herbs | | 1 | 2 |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | 1 | 2 |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | 3 |
| | Plantation | | | |

| Water Quality | | | | | |
|---|---|---|---|---|---|
| **Salinity** | Fresh (<500 mS/m) | **19.5** | Temperature | **°C** | **30.4** |
| | Brackish (500-3000 mS/m) | | Dissolved Oxygen | **mg/ℓ** | **3.6** |
| | Saline (3000-8000 mS/m) | | | **%** | **54.9** |
| | Hypersaline (>8000 mS/m) | | Conductivity | **∓S/cm** | **195.0** |
| **pH** | Acidic (<6) | | Water Clarity | **cm** | |
| | Circum-neutral (6-8) | | | | |
| | Alkaline (>8) | **8.1** | | | |

**Catchment Land-use**

A summary of catchment land-use likely to affect surface waters.

| Land-use | (0-6) |
|---|---|
| Conservation/Wilderness | |
| Livestock - Grazing | 6 |
| Mining - Underground | |
| Forestry | |
| Recreation | 3 |
| Cultivation - Dryland | 5 |
| Cultivation - Irrigated | |
| Residential - Rural | 4 |
| Residential - Urban | |
| Commercial | |
| Industrial - Light | |
| Industrial - Heavy | |
| Livestock - Feedlots | |
| Mining - Open | |
| Other | |

**Catchment Disturbance**

A summary of catchment disturbances rated from natural to critical.

| | *Natural* | | | | | *Critical* |
|---|---|---|---|---|---|---|
| **Parameter** | **Zero** | **VL** | **Low** | **Mod** | **High** | **VH** |
| Catchment | | | | | | x |
| Roads/Bridges/Culverts | | | | | x | |
| Impoundments/Weirs | | | | | | x |
| Livestock | | | | | x | |
| Fire | | | | | | |
| Sewage Fungus | | | | | | |
| Algae - Benthic | | | | | | |
| Algae - Planktonic | | | | | | |
| Macrophytes | | | | | | |
| Hydrocarbons | | | | x | | |
| Turbidity | | | | | | x |
| Colour | | | | | | x |
| Odour | | | | x | | |
| Temperature | | | | x | | |
| Foam | x | | | | | |
| pH | | x | | | | |
| Other | | | | | | |

***SITE RV-02: Nkhuzi River***

Habitat photos of the Nkhuzi River.

**Up- and downstream views of the Limphangwi River (18 January 2016). The left photograph is facing upstream (above the bridge) and the right photo downstream (below the bridge).**

**View of the mid-channel of the Limphangwi River, highlighting the high soil-gravel deposition upstream from the bridge (18 January 2016).**

**View of the river downstream from the bridge, which is collapsing, and serves as a barrier to upstream fish movement during low flow conditions (18 January 2016).**

**Site Information**

Relevant site location details.

| **Site Code:** | RV-02 | **Date:** | 18 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.15414° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 34.97163° E | **Elevation:** | 80-100 m a.s.l. |

| **Hydro-geomorphic Unit** | | |
|---|---|---|
| **Unit** | **Type** | **Landform** |
| River | Upper Foothill | Active Channel/Riparian Zone |

| **Biotopes** | | | | | |
|---|---|---|---|---|---|
| **Hydraulic** | | | **Substrates** | | |
| **Inundation** | Permanent | **x** | **Organic** | Leaves/Detritus | **1** |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | **2** |
| | Cascade | | | Loam | |
| | Rapid | **1** | | Silt | **5** |
| | Riffle | **3** | | Sand – Fine | **2** |
| | Run | **4** | | Sand - Coarse | **2** |
| | Glide | **3** | **Rocky** | Gravel – F (2-8) | **4** |
| | Pool | **2** | | Gravel – M (8-16) | **3** |
| | Backwater | **2** | | Gravel - C (16–64) | **3** |
| **Artificial** | Canal | | | Cobble – Small (64-128) | **3** |
| | Dam (in-channel) | | | Cobble – Large (128-250) | **2** |
| | Dam (off-channel) | | | Boulder – Small (250-500) | **1** |
| | Excavation | | | Boulder – Med (500-1000) | **1** |
| | Salt Works | | | Boulder – Large (1000-4000) | **1** |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| Cover | | Water | Marginal | Riparian |
| **Aquatic** | Floating | | | |
| | Submerged | | | |
| | Emergent | 1 | | |
| **Herbaceous** | Bare | | 3 | 2 |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | | 3 | 2 |
| | Herbs | | 1 | 2 |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | 1 | 2 |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | 3 |
| | Plantation | | | |

| Water Quality | | | | | |
|---|---|---|---|---|---|
| **Salinity** | Fresh (<500 mS/m) | **32.2** | **Temperature** | °C | **28.6** |
| | Brackish (500-3000 mS/m) | | **Dissolved Oxygen** | mg/ℓ | **3.3** |
| | Saline (3000-8000 mS/m) | | | % | **47.7** |
| | Hypersaline (>8000 mS/m) | | **Conductivity** | ∓S/cm | **320.0** |
| **pH** | Acidic (<6) | | **Water Clarity** | cm | |
| | Circum-neutral (6-8) | | | | |
| | Alkaline (>8) | **8.2** | | | |

**Catchment Land-use**

A summary of catchment land-use likely to affect surface waters.

| Land-use | (0-6) |
|---|---|
| Conservation/Wilderness | |
| Livestock - Grazing | 6 |
| Mining - Underground | |
| Forestry | |
| Recreation | 3 |
| Cultivation - Dryland | 5 |
| Cultivation - Irrigated | |
| Residential - Rural | 4 |
| Residential - Urban | |
| Commercial | |
| Industrial - Light | |
| Industrial - Heavy | |
| Livestock - Feedlots | |
| Mining - Open | |
| Other | |

**Catchment Disturbance**

A summary of catchment disturbances rated from natural to critical.

| | *Natural* | | | | | *Critical* |
|---|---|---|---|---|---|---|
| **Parameter** | **Zero** | **VL** | **Low** | **Mod** | **High** | **VH** |
| Catchment | | | | | | x |
| Roads/Bridges/Culverts | | | | | x | |
| Impoundments/Weirs | | | | x | | |
| Livestock | | | | | x | |
| Fire | | | | | | |
| Sewage Fungus | | | | | | |
| Algae - Benthic | | | | | | |
| Algae - Planktonic | | | | | | |
| Macrophytes | | | | | | |
| Hydrocarbons | | | | x | | |
| Turbidity | | | | | | x |
| Colour | | | | | | x |
| Odour | | | | x | | |
| Temperature | | | | x | | |
| Foam | x | | | | | |
| pH | x | | | | | |
| Other | | | | | | |

***SITE RV-03: Maperera River***

Habitat photos of the Maperera River.

**Up- and downstream views of the Maperea River (18 January 2016). The left photograph is facing upstream from the bridge on the S152 towards the falls and the right photo downstream from the bridge.**

**View of the road approach to the left stream bank of the Maperea River (18 January 2016).**

**View of the road approach from the right stream bank of the Maperea River (18 January 2016).**

**Site Information**

Relevant site location details.

| **Site Code:** | RV-03 | **Date:** | 18 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.09683° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 34.91168° E | **Elevation:** | 80-100 m a.s.l. |

| **Hydro-geomorphic Unit** | | |
|---|---|---|
| **Unit** | **Type** | **Landform** |
| River | Upper Foothill | Active Channel/Riparian Zone |

| **Biotopes** | | | | | |
|---|---|---|---|---|---|
| **Hydraulic** | | | **Substrates** | | |
| **Inundation** | Permanent | x | **Organic** | Leaves/Detritus | 1 |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | 1 | | Clay | 1 |
| | Cascade | 1 | | Loam | |
| | Rapid | 1 | | Silt | 5 |
| | Riffle | 2 | | Sand – Fine | 3 |
| | Run | 3 | | Sand - Coarse | 4 |
| | Glide | 4 | **Rocky** | Gravel – F (2-8) | 3 |
| | Pool | 4 | | Gravel – M (8-16) | 3 |
| | Backwater | 1 | | Gravel - C (16–64) | 3 |
| **Artificial** | Canal | | | Cobble – Small (64-128) | 2 |
| | Dam (in-channel) | | | Cobble – Large (128-250) | 2 |
| | Dam (off-channel) | | | Boulder – Small (250-500) | 2 |
| | Excavation | | | Boulder – Med (500-1000) | 1 |
| | Salt Works | | | Boulder – Large (1000-4000) | 1 |
| | Pond (e.g. WWTW) | | | Bedrock | 1 |
| | Irrigated Land | | | Waterfall | 1 |

| Vegetation | | | | |
|---|---|---|---|---|
| **Cover** | | **Water** | **Marginal** | **Riparian** |
| **Aquatic** | Floating | | | |
| | Submerged | | | |
| | Emergent | 1 | | |
| **Herbaceous** | Bare | | 3 | 2 |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | | 2 | 2 |
| | Herbs | | | 2 |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | 1 | 2 |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | 3 |
| | Plantation | | | |

| Water Quality | | | | | |
|---|---|---|---|---|---|
| **Salinity** | Fresh (<500 mS/m) | **14.6** | **Temperature** | °C | **27.8** |
| | Brackish (500-3000 mS/m) | | **Dissolved Oxygen** | mg/ℓ | **3.69** |
| | Saline (3000-8000 mS/m) | | | % | **52.3** |
| | Hypersaline (>8000 mS/m) | | **Conductivity** | ∓S/cm | **145.8** |
| **pH** | Acidic (<6) | | **Water Clarity** | cm | |
| | Circum-neutral (6-8) | **7.8** | | | |
| | Alkaline (>8) | | | | |

**Catchment Land-use**

A summary of catchment land-use likely to affect surface waters.

| **Land-use** | **(0-6)** |
|---|---|
| Conservation/Wilderness | |
| Livestock - Grazing | 5 |
| Mining - Underground | |
| Forestry | |
| Recreation | 3 |
| Cultivation - Dryland | 3 |
| Cultivation - Irrigated | |
| Residential - Rural | 4 |
| Residential - Urban | |
| Commercial | |
| Industrial - Light | |
| Industrial - Heavy | |
| Livestock - Feedlots | |
| Mining - Open | |
| Other | |

**Catchment Disturbance**

A summary of catchment disturbances rated from natural to critical.

| | ***Natural*** | | | | | ***Critical*** |
|---|---|---|---|---|---|---|
| **Parameter** | **Zero** | **VL** | **Low** | **Mod** | **High** | **VH** |
| Catchment | | | | | x | |
| Roads/Bridges/Culverts | | | | | x | |
| Impoundments/Weirs | | | | | | |
| Livestock | | | | | x | |
| Fire | | | | | | |
| Sewage Fungus | | | | | | |
| Algae - Benthic | | | | | | |
| Algae - Planktonic | | | | | | |
| Macrophytes | | | | | | |
| Hydrocarbons | | | | x | | |
| Turbidity | | | | | | x |
| Colour | | | | | | x |
| Odour | | | x | | | |
| Temperature | | | | x | | |
| Foam | x | | | | | |
| pH | x | | | | | |
| Other | | | | | | |

***SITE RV-04: Limphangwi River***

Habitat photos of the Limphangwi River.

**Up- and downstream views of the Limphangwi River (18 January 2016). The left photograph is facing upstream from the bridge on the S152 and the right photo downstream from the bridge.**

View of the mid-channel of the Limphangwi River, highlighting the high soil-gravel deposition upstream from the bridge (18 January 2016).

View of the river downstream from the bridge, which is collapsing, and serves as a barrier to upstream fish movement during low flow conditions (18 January 2016).

**Site Information**

Relevant site location details.

| | | | |
|---|---|---|---|
| **Site Code:** | RV-04 | **Date:** | 18 January 2016 |
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.15414° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 34.97163° E | **Elevation:** | 80-100 m a.s.l. |

| Hydro-geomorphic Unit | | |
|---|---|---|
| **Unit** | **Type** | **Landform** |
| River | Upper Foothill | Active Channel/Riparian Zone |

| Biotopes | | | | | |
|---|---|---|---|---|---|
| **Hydraulic** | | | **Substrates** | | |
| **Inundation** | Permanent | x | **Organic** | Leaves/Detritus | 1 |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | 2 |
| | Cascade | | | Loam | |
| | Rapid | 1 | | Silt | 5 |
| | Riffle | 3 | | Sand – Fine | 2 |
| | Run | 4 | | Sand - Coarse | 2 |
| | Glide | 3 | **Rocky** | Gravel – F (2-8) | 4 |
| | Pool | 2 | | Gravel – M (8-16) | 3 |
| | Backwater | 2 | | Gravel - C (16–64) | 3 |
| **Artificial** | Canal | | | Cobble – Small (64-128) | 3 |
| | Dam (in-channel) | | | Cobble – Large (128-250) | 2 |
| | Dam (off-channel) | | | Boulder – Small (250-500) | 1 |
| | Excavation | | | Boulder – Med (500-1000) | 1 |
| | Salt Works | | | Boulder – Large (1000-4000) | 1 |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| | Cover | Water | Marginal | Riparian |
| **Aquatic** | Floating | | | |
| | Submerged | | | |
| | Emergent | 1 | | |
| **Herbaceous** | Bare | | 3 | 2 |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | | 3 | 2 |
| | Herbs | | 1 | 2 |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | 1 | 2 |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | 3 |
| | Plantation | | | |

| Water Quality | | | | | |
|---|---|---|---|---|---|
| **Salinity** | Fresh (<500 mS/m) | **17.6** | **Temperature** | °C | **30.9** |
| | Brackish (500-3000 mS/m) | | **Dissolved Oxygen** | mg/ℓ | **3.8** |
| | Saline (3000-8000 mS/m) | | | % | **56.8** |
| | Hypersaline (>8000 mS/m) | | **Conductivity** | ∓S/cm | **176.0** |
| **pH** | Acidic (<6) | | **Water Clarity** | cm | |
| | Circum-neutral (6-8) | **8.0** | | | |
| | Alkaline (>8) | | | | |

**Catchment Land-use**

A summary of catchment land-use likely to affect surface waters.

| Land-use | (0-6) |
|---|---|
| Conservation/Wilderness | |
| Livestock - Grazing | 6 |
| Mining - Underground | |
| Forestry | |
| Recreation | 3 |
| Cultivation - Dryland | 5 |
| Cultivation - Irrigated | |
| Residential - Rural | 4 |
| Residential - Urban | |
| Commercial | |
| Industrial - Light | |
| Industrial - Heavy | |
| Livestock - Feedlots | |
| Mining - Open | |
| Other | |

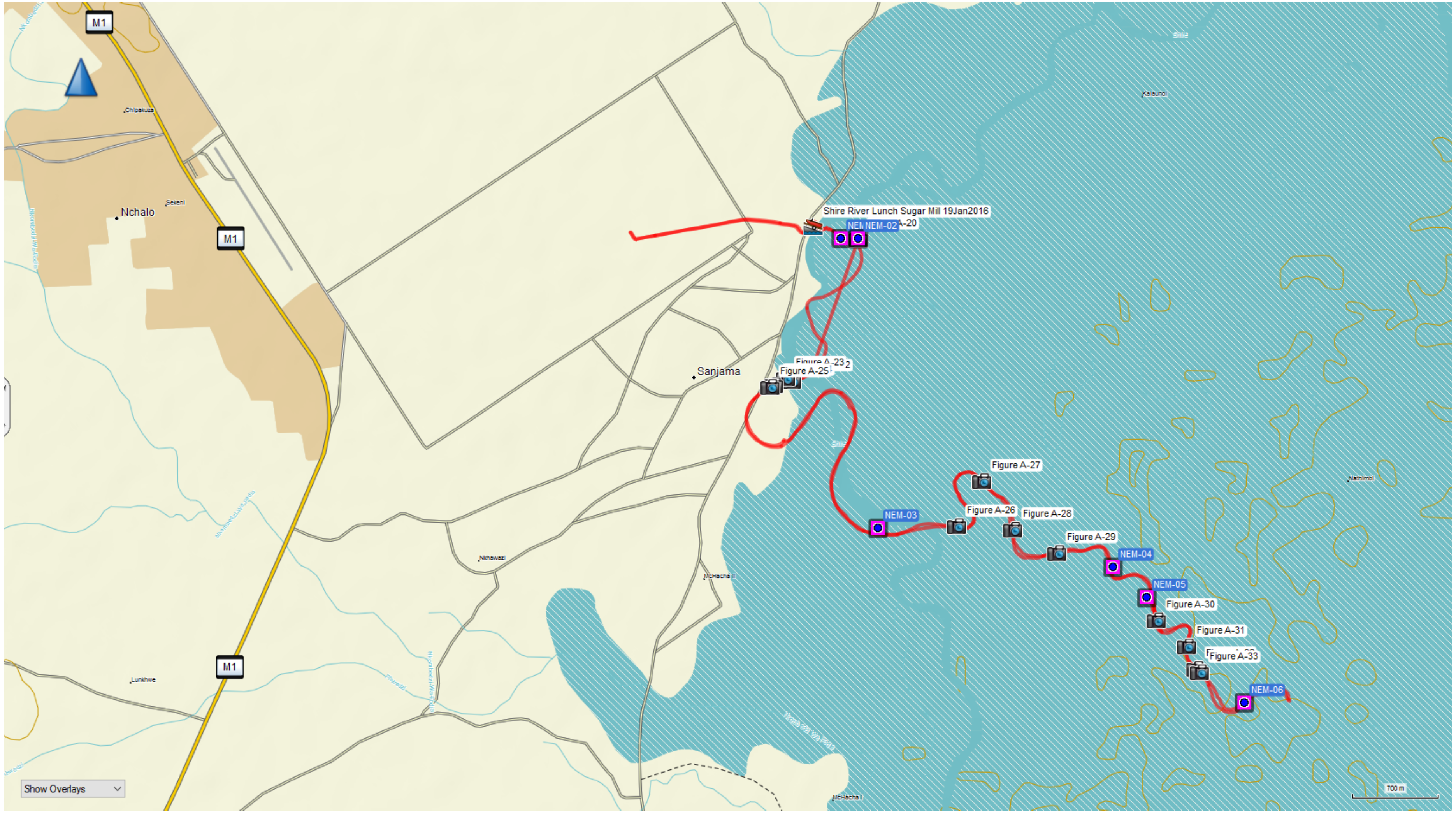
**Catchment Disturbance**

A summary of catchment disturbances rated from natural to critical.

| | *Natural* | | | | | *Critical* |
|---|---|---|---|---|---|---|
| **Parameter** | **Zero** | **VL** | **Low** | **Mod** | **High** | **VH** |
| Catchment | | | | | | x |
| Roads/Bridges/Culverts | | | | | x | |
| Impoundments/Weirs | | | | x | | |
| Livestock | | | | | x | |
| Fire | | | | | | |
| Sewage Fungus | | | | | | |
| Algae - Benthic | | | | | | |
| Algae - Planktonic | | | | | | |
| Macrophytes | | | | | | |
| Hydrocarbons | | | | x | | |
| Turbidity | | | | | | x |
| Colour | | | | | | x |
| Odour | | | | x | | |
| Temperature | | | | x | | |
| Foam | x | | | | | |
| pH | x | | | | | |
| Other | | | | | | |

## Site 3. North-western portion of the Elephant Marsh

Site 3 is located in the upper north-western portion of the Elephant Marshes (NEM). A small boat was launched into the water at 08h43 and due to problems with the engine, the boat returned to the launch site at 14h07. During this period, six different micro-habitat sites were sampled. The photos that follow indicate some of the habitat sampled, and indicate general characteristics of the area sampled.




**Topo-cadastral map roughly indicating the location of site locations for Site 3: north-eastern portion of the Elephant Marsh**

**Upstream view of the Shire River from the launch site on the left, and downstream view on the right (S16.27052 & E34.92059, 19 January 2016).**

**View of the marginal vegetation (*Phragmites*) sampled (NEM-02) at the right edge (facing downstream) of the Shire River. The reed structure is constructed by local fishermen for fishing access (S016.27138 & E034.92405, 19 January 2016).**

**River bank on inner edge of rivers' flow curve, with deposition on the bend and scoured banks on the outer channel edge (19 January 2016).**

Dumping of organic and some domestic waste on river banks and into the river. Dolosse is visible on the stream bank most likely brought in as an effort to prevent or control further bank scouring and collapse (S16.28171 & E34.91893, 19 January 2016).

View of the aquatic grasses and mud banks formed after collapse (S016.28184 & E034.91843, 19 January 2016).

**Local children fishing from the bank edges of the Shire River (S016.28202 & E034.91753, 19 January 2016).**

**Wake of the boat causing further bank collapse (S016.28213 & E034.91722, 19 January 2016).**

Recent collapse of termitaria on the scoured edge of the river bank (S016.29229 & E034.93166, 19 January 2016).

Soil layers exposed in the recently scoured banks of the Shire River (S016.18898 & E034.93166, 19 January 2016).

**Recent collapse of *Phragmites* banks into the river (S016.29249 & E034.93599, 19 January 2016).**

**Backwater pool dominated by mud-banks (S016.29419 & E034.93953, 19 January 2016).**

River bank dominated by hippo grasses (S016.29911 & E034.94713, 19 January 2016).


A view of the red-brown water, which were also full of organic material of different sizes (S016.30102 & E034.94941). Water clarity was measured as 2cm at all six the sampling points (19 January 2016).

**View of river edge with shrub and Phragmites dominated bank (S016.30261 & E034.95014, 19 January 2016).**

**Edge of Phragmites dominated backwater with floating organic material and aquatic free floating vegetation such as *Pistia stratiotes* and *Eichhornia crassipes* (S016.30291 & E034.95044, 19 January 2016).**

Hydro-geomorphic unit, water quality, catchment land-use, catchment disturbance and habitat integrity are summarised for all of the six the sampled sites in the north-western portion of the Elephant Marsh, since the change in land-use between the sites was considered insignificant. These are presented in the four tables below.

| Hydro-geomorphic Unit | | |
|---|---|---|
| **Unit** | **Type** | **Landform** |
| River | Lowland River | Active Channel/Riparian Zone |

| Water Quality | | | | | |
|---|---|---|---|---|---|
| **Salinity** | Fresh (<500 mS/m) | **21.1 – 21.9** | **Temperature** | °C | **27.5 – 28.4** |
| | Brackish (500-3000 mS/m) | | **Dissolved Oxygen** | mg/ℓ | **2.4 – 3.0** |
| | Saline (3000-8000 mS/m) | | | % | **34.3 – 42.0** |
| | Hypersaline (>8000 mS/m) | | **Conductivity** | ∓S/cm | **211 - 219** |
| **pH** | Acidic (<6) | | **Water Clarity** | cm | **2** |
| | Circum-neutral (6-8) | **7.6 – 7.8** | | | |
| | Alkaline (>8) | | | | |

**Catchment Land-use**

A summary of catchment land-use likely to affect surface waters at sites NEM-01 to 06.

| **Land-use** | **(0-6)** |
|---|---|
| Conservation/Wilderness | |
| Livestock - Grazing | 6 |
| Mining - Underground | |
| Forestry | |
| Recreation | 3 |
| Cultivation - Dryland | 5 |
| Cultivation - Irrigated | |
| Residential - Rural | 4 |
| Residential - Urban | 3 |
| Commercial | 2 |
| Industrial - Light | 2 |
| Industrial - Heavy | 3 |
| Livestock - Feedlots | |
| Mining - Open | |
| Other | |

**Catchment Disturbance**

A summary of catchment disturbances at sites NEM-01 to 06, rated from natural to critical.

| | ***Natural*** | | | | | ***Critical*** |
|---|---|---|---|---|---|---|
| **Parameter** | **Zero** | **VL** | **Low** | **Mod** | **High** | **VH** |
| Catchment | | | | | | x |
| Roads/Bridges/Culverts | | | | | x | |
| Impoundments/Weirs | | | x | | | |
| Livestock | | | | | x | |
| Fire | | | | | | |
| Sewage Fungus | | | | | | |
| Algae - Benthic | | | | | | |
| Algae - Planktonic | | | | | | |
| Macrophytes | | | | x | | |
| Hydrocarbons | | x | | | | |
| Turbidity | | | | | | x |
| Colour | | | | | | x |
| Odour | | x | | | | |
| Temperature | | | | x | | |
| Foam | x | | | | | |
| pH | x | | | | | |
| Other | | | | | | |

### *SITE NEM-01*

This sampling point was located on the main Shire River channel, close to the launch site. The dominant biotopes sampled were reeds, aquatic grasses and mud.

#### Site Information

Relevant site location details.

| **Site Code:** | NEM-01 | **Date:** | 19 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.27129° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 34.92272° E | **Elevation:** | 40-60 m a.s.l. |

| **Biotopes** | | | | | |
|---|---|---|---|---|---|
| **Hydraulic** | | | **Substrates** | | |
| **Inundation** | Permanent | **6** | **Organic** | Leaves/Detritus | **1** |
| | Seasonal | | | Organic | **2** |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | **5** |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | |
| | Riffle | | | Sand – Fine | |
| | Run | **4** | | Sand - Coarse | |
| | Glide | **2** | **Rocky** | Gravel – F (2-8) | |
| | Pool | | | Gravel – M (8-16) | |
| | Backwater | **2** | | Gravel - C (16–64) | |
| **Artificial** | Canal | | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| Cover | | **Water** | **Marginal** | **Riparian** |
| **Aquatic** | Floating | 1 | 1 | |
| | Submerged | 2 | 2 | |
| | Emergent | 5 | 5 | |
| **Herbaceous** | Bare | | | |
| | Crops | | | 2 |
| | Geophytes | | | |
| | Grasses | | 1 | 4 |
| | Herbs | | 3 | 5 |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | 5 | 2 |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | | 2 |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | 1 |
| | Plantation | | | |

### *SITE NEM-02*

This sampling point was located on the left banks of the Shire River (facing downstream). The dominant biotopes sampled were aquatic grasses.

#### Site Information

Relevant site location details.

| Site Code: | NEM-02 | Date: | 19 January 2016 |
|---|---|---|---|
| | | **LOCATION** | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.27132° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 34.92406° E | **Elevation:** | 40-60 m a.s.l. |

| Biotopes | | | | | |
|---|---|---|---|---|---|
| **Hydraulic** | | | **Substrates** | | |
| **Inundation** | Permanent | **6** | **Organic** | Leaves/Detritus | **1** |
| | Seasonal | | | Organic | **2** |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | **5** |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | **1** |
| | Riffle | | | Sand – Fine | **2** |
| | Run | **4** | | Sand - Coarse | |
| | Glide | **2** | **Rocky** | Gravel – F (2-8) | |
| | Pool | | | Gravel – M (8-16) | |
| | Backwater | **2** | | Gravel - C (16–64) | |
| **Artificial** | Canal | | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| **Cover** | | **Water** | **Marginal** | **Riparian** |
| **Aquatic** | Floating | 1 | 1 | |
| | Submerged | 1 | 2 | |
| | Emergent | 5 | 5 | |
| **Herbaceous** | Bare | 1 | 1 | |
| | Crops | | | 2 |
| | Geophytes | | | |
| | Grasses | 5 | 4 | 4 |
| | Herbs | | 1 | 5 |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | | 1 |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | 1 |
| | Plantation | | | |

### *SITE NEM-03*

The sampling point was located in aquatic grasses in backwaters located on the left river bank of the Shire River. The dominant biotopes sampled were vegetation.

**Site Information**

Relevant site location details.

| **Site Code:** | NEM-03 | **Date:** | 19 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.29240° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 34.92558° E | **Elevation:** | 40-60 m a.s.l. |

| **Biotopes** | | | | | |
|---|---|---|---|---|---|
| **Hydraulic** | | | **Substrates** | | |
| **Inundation** | Permanent | 6 | **Organic** | Leaves/Detritus | |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | |
| | Riffle | | | Sand – Fine | |
| | Run | | | Sand - Coarse | |
| | Glide | 1 | **Rocky** | Gravel – F (2-8) | |
| | Pool | | | Gravel – M (8-16) | |
| | Backwater | 4 | | Gravel - C (16–64) | |
| **Artificial** | Canal | | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | | |
|---|---|---|---|---|---|
| | Cover | Water | Marginal | Riparian |
| **Aquatic** | Floating | | | |
| | Submerged | | | |
| | Emergent | | | |
| **Herbaceous** | Bare | | | |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | 4 | 4 | |
| | Herbs | | | |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | | |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | |
| | Plantation | | | |

### *SITE NEM-04*

The sampling point was located in the backwaters on mud below the eroded left river bank of the Shire River. The dominant biotopes sampled were mud.

#### Site Information

Relevant site location details.

| **Site Code:** | NEM-04 | **Date:** | 19 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.29522° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 34.94373° E | **Elevation:** | 40-60 m a.s.l. |

| Biotopes | | | | | |
|---|---|---|---|---|---|
| **Hydraulic** | | | **Substrates** | | |
| **Inundation** | Permanent | 6 | **Organic** | Leaves/Detritus | |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | 5 |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | |
| | Riffle | | | Sand – Fine | |
| | Run | | | Sand - Coarse | |
| | Glide | | **Rocky** | Gravel – F (2-8) | |
| | Pool | | | Gravel – M (8-16) | |
| | Backwater | 4 | | Gravel - C (16–64) | |
| **Artificial** | Canal | | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| **Cover** | | **Water** | **Marginal** | **Riparian** |
| **Aquatic** | Floating | | | |
| | Submerged | | | |
| | Emergent | | | |
| **Herbaceous** | Bare | 5 | 5 | |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | | | |
| | Herbs | | | |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | | |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | |
| | Plantation | | | |

### *SITE NEM-05*

The sampling point was located within aquatic grasses on the right river bank of the Shire River. The dominant biotopes sampled were aquatic grasses (*Vossia cuspidata*).

#### Site Information

Relevant site location details.

| **Site Code:** | NEM-05 | **Date:** | 19 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.29745° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 34.94635° E | **Elevation:** | 40-60 m a.s.l. |

| Biotopes | | | | | |
|---|---|---|---|---|---|
| **Hydraulic** | | | **Substrates** | | |
| **Inundation** | Permanent | 6 | **Organic** | Leaves/Detritus | |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | |
| | Riffle | | | Sand – Fine | |
| | Run | | | Sand - Coarse | |
| | Glide | 4 | **Rocky** | Gravel – F (2-8) | |
| | Pool | | | Gravel – M (8-16) | |
| | Backwater | | | Gravel - C (16–64) | |
| **Artificial** | Canal | | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| Cover | | Water | Marginal | Riparian |
| **Aquatic** | Floating | | | |
| | Submerged | 3 | 3 | |
| | Emergent | 5 | 5 | |
| **Herbaceous** | Bare | | | |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | 5 | 5 | |
| | Herbs | | | |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | | |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | |
| | Plantation | | | |

### *SITE NEM-06*

The sampling point was located on a sand-mud bank located on the right bank (Facing downstream) of the Shire River. The dominant biotopes sampled were aquatic grasses, sand and mud.

**Site Information**

Relevant site location details.

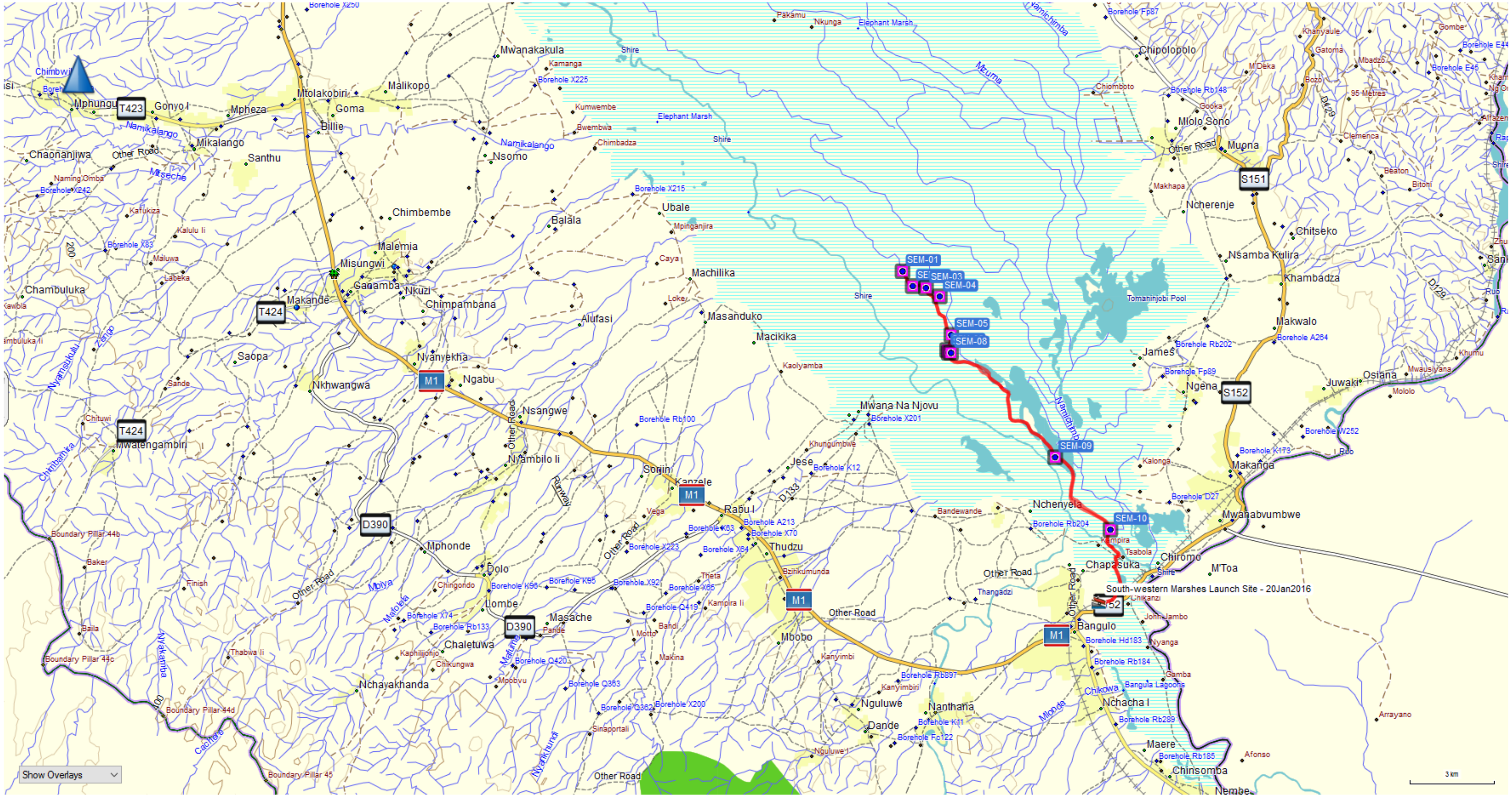
| **Site Code:** | NEM-06 | **Date:** | 19 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.30508° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 34.95388° E | **Elevation:** | 40-60 m a.s.l. |

| Biotopes | | | | | |
|---|---|---|---|---|---|
| **Hydraulic** | | | **Substrates** | | |
| **Inundation** | Permanent | 6 | **Organic** | Leaves/Detritus | |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | |
| | Riffle | | | Sand – Fine | |
| | Run | 4 | | Sand - Coarse | |
| | Glide | 2 | **Rocky** | Gravel – F (2-8) | |
| | Pool | | | Gravel – M (8-16) | |
| | Backwater | 2 | | Gravel - C (16–64) | |
| **Artificial** | Canal | | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| **Vegetation** | | | | |
|---|---|---|---|---|
| **Cover** | | **Water** | **Marginal** | **Riparian** |
| **Aquatic** | Floating | 4 | 1 | |
| | Submerged | 3 | 3 | |
| | Emergent | 2 | 2 | |
| **Herbaceous** | Bare | | | |
| | Crops | | | 2 |
| | Geophytes | | | |
| | Grasses | 3 | 3 | 4 |
| | Herbs | | 1 | 5 |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | | 1 |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | 1 |
| | Plantation | | | |

## Site 4. South-western portion of the Elephant Marsh

A slightly larger boat (than used for the NEM sites) was launched into the water at 09h40 and returned to the launch site at 17h48. During this period, ten different micro-habitat sites (SEM) were sampled. An insert of a topo-cadastral map roughly indicating the location of the three sampling locations is shown below. (Copied from Garmin BaseCamp Version 4.4.7, Garmap Southern Africa TOPO 2013 PRO). The photos that follow indicate some of the habitat sampled, and indicate general characteristics of the area sampled.




**Topo-cadastral map roughly indicating the location of the three sampling locations for Site 4: South-western portion of the Elephant Marsh**

**Upstream view of the Shire River close the launch site (S16.55820 & E35.13549) on the left, and an upstream view of the first papyrus encountered seven kilometers further upstream (S16.50598 & E35.09971; 20 January 2016).**


**An up- and downstream view of the SEM-07 site, sampled where the clear water from the WEM sites meet with the Shire River. The upstream view is on the left and the downstream view on the right (S016.48449 & E035.07773, 20 January 2016). The vegetation was sampled and the taxa diversity was the highest recorded in the study area. Large numbers of small fish were also noted.**

A view of floating aquatic vegetation sampled at the bottom edge of a braided channel (S16.48417 & E35.07795, 20 January 2016).

View of papyrus on the left bank (S16.47485 & E035.07653, 20 January 2016).

**Marginal vegetation dominated by papyrus on the right stream bank edges of the Shire River (S16.47440 & E35.07655, 20 January 2016).**

**View of the sampling location in the vicinity of the SEM-04 sampling point (S16.46670 & E35.07400, 20 January 2016).**

**High quantities of water hyacinth were floating downstream, indicating upstream dislodgement, likely as a result of increased flow. The marginal vegetation to the right was sampled (SEM-02), with the vegetation dominated by Phragmites (S16.462331 & 35.06567, 20 January 2016).**

**View of the habitat sampled at the SEM-03 site (20 January 2016).**

**Marginal vegetation on the right stream bank (S16.46924 & E34.07362, 20 January 2016).**

**A view of a backwater portion of the Shire River in the Elephant Marshes with clear water. The hornwort and water lilies is also indicative of extended periods of clear water with very slow to stagnant waters (S16.48737 & E35.08392, 20 January 2016).**

View of river edge with aquatic grasses in flow dominating the river bank (S16.52924 & E35.11873, 20 January 2016).

Large expanse of aquatic vegetation just off the main channel of the Shire River (S16.55246 & E35.13342, 20 January 2016).

Hydro-geomorphic unit, water quality, catchment land-use, catchment disturbance and habitat integrity are summarised for all ten of the sampled sites in this south-western portion of the Elephant Marsh because the change in land-use between the sites was considered insignificant. Results are presented in the four tables that follows.

| Hydro-geomorphic Unit | | |
|---|---|---|
| **Unit** | **Type** | **Landform** |
| River-Floodplain | Lowland River | Braided Channels/Floodplain |

| Water Quality | | | | | |
|---|---|---|---|---|---|
| **Salinity** | Fresh (<500 mS/m) | **17.2 – 28.6** | **Temperature** | °C | **27.3 – 29.7** |
| | Brackish (500-3000 mS/m) | | **Dissolved Oxygen** | mg/ℓ | **0.7 – 4.5** |
| | Saline (3000-8000 mS/m) | | | % | **9.8 – 66.0** |
| | Hypersaline (>8000 mS/m) | | **Conductivity** | ∓S/cm | **172 – 286** |
| **pH** | Acidic (<6) | | **Water Clarity** | cm | **5 - >120** |
| | Circum-neutral (6-8) | **6.7 – 7.5** | | | |
| | Alkaline (>8) | | | | |

**Catchment Land-use**

A summary of catchment land-use likely to affect surface waters at sites SEM-01 to 10.

| **Land-use** | **(0-6)** |
|---|---|
| Conservation/Wilderness | |
| Livestock - Grazing | 6 |
| Mining - Underground | |
| Forestry | |
| Recreation | 3 |
| Cultivation - Dryland | 5 |
| Cultivation - Irrigated | |
| Residential - Rural | 4 |
| Residential - Urban | 3 |
| Commercial | 2 |
| Industrial - Light | 2 |
| Industrial - Heavy | 3 |
| Livestock - Feedlots | |
| Mining - Open | |
| Other | |

### Catchment Disturbance

A summary of catchment disturbances at sites SEM-01 to 10, rated from natural to critical.

| | *Natural* | | | | | *Critical* |
|---|---|---|---|---|---|---|
| **Parameter** | **Zero** | **VL** | **Low** | **Mod** | **High** | **VH** |
| Catchment | | | | | x | |
| Roads/Bridges/Culverts | | | | | x | |
| Impoundments/Weirs | | | x | | | |
| Livestock | | | | | x | |
| Fire | | | | | | |
| Sewage Fungus | | | | | | |
| Algae - Benthic | | | | | | |
| Algae - Planktonic | | | | | | |
| Macrophytes | | | | x | | |
| Hydrocarbons | | x | | | | |
| Turbidity | | | | | | x |
| Colour | | | | | | x |
| Odour | | x | | | | |
| Temperature | | | | x | | |
| Foam | x | | | | | |
| pH | x | | | | | |
| Other | | | | | | |

### *SITE SEM-01*

The sampling point was located in marginal vegetation close to the mud-organic substrate.

### Site Information

Relevant site location details.

| **Site Code:** | SEM-01 | **Date:** | 20 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.45862° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 35.06226° E | **Elevation:** | 40-60 m a.s.l. |

| Biotopes | | | | | |
|---|---|---|---|---|---|
| Hydraulic | | | Substrates | | |
| **Inundation** | Permanent | 6 | **Organic** | Leaves/Detritus | 3 |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | 3 |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | |
| | Riffle | | | Sand – Fine | |
| | Run | 2 | | Sand - Coarse | |
| | Glide | 3 | **Rocky** | Gravel – F (2-8) | |
| | Pool | | | Gravel – M (8-16) | |
| | Backwater | 2 | | Gravel - C (16–64) | |
| **Artificial** | Canal | | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| Cover | | Water | Marginal | Riparian |
| **Aquatic** | Floating | 4 | 2 | |
| | Submerged | 3 | 3 | |
| | Emergent | 3 | 4 | |
| **Herbaceous** | Bare | | | |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | 3 | 3 | |
| | Herbs | | 1 | |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | | |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | |
| | Plantation | | | |

## *SITE SEM-02*

The sampling point was located in emergent and aquatic marginal vegetation.

### Site Information

Relevant site location details.

| **Site Code:** | SEM-02 | **Date:** | 20 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.46333° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 35.06567° E | **Elevation:** | 40-60 m a.s.l. |

| **Biotopes** | | | | | |
|---|---|---|---|---|---|
| **Hydraulic** | | | **Substrates** | | |
| **Inundation** | Permanent | 6 | **Organic** | Leaves/Detritus | |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | |
| | Riffle | | | Sand – Fine | |
| | Run | 1 | | Sand - Coarse | |
| | Glide | 2 | **Rocky** | Gravel – F (2-8) | |
| | Pool | | | Gravel – M (8-16) | |
| | Backwater | 3 | | Gravel - C (16–64) | |
| **Artificial** | Canal | | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| Cover | | Water | Marginal | Riparian |
| **Aquatic** | Floating | 4 | 2 | |
| | Submerged | 3 | 3 | |
| | Emergent | 3 | 4 | |
| **Herbaceous** | Bare | | | |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | 3 | 3 | |
| | Herbs | | | |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | | |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | |
| | Plantation | | | |

### *SITE SEM-03*

The sampling point was located in papyrus with emergent grasses.

#### Site Information

Relevant site location details.

| **Site Code:** | SEM-03 | **Date:** | 20 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.46391° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 35.07011° E | **Elevation:** | 40-60 m a.s.l. |

| Biotopes | | | | | |
|---|---|---|---|---|---|
| Hydraulic | | | Substrates | | |
| **Inundation** | Permanent | 6 | **Organic** | Leaves/Detritus | |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | |
| | Riffle | | | Sand – Fine | |
| | Run | 1 | | Sand - Coarse | |
| | Glide | 3 | **Rocky** | Gravel – F (2-8) | |
| | Pool | | | Gravel – M (8-16) | |
| | Backwater | 2 | | Gravel - C (16–64) | |
| **Artificial** | Canal | | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| Cover | | Water | Marginal | Riparian |
| **Aquatic** | Floating | 4 | 3 | |
| | Submerged | 3 | 3 | |
| | Emergent | 3 | 4 | |
| **Herbaceous** | Bare | | | |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | 2 | 3 | |
| | Herbs | | | |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | | |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | |
| | Plantation | | | |

### *SITE SEM-04*

The sampling point was located in emergent and aquatic marginal vegetation on side channel.

#### Site Information

Relevant site location details.

| **Site Code:** | SEM-04 | **Date:** | 20 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.46661° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 35.07472° E | **Elevation:** | 40-60 m a.s.l. |

| **Biotopes** | | | | | |
|---|---|---|---|---|---|
| **Hydraulic** | | | **Substrates** | | |
| **Inundation** | Permanent | 6 | **Organic** | Leaves/Detritus | |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | |
| | Riffle | | | Sand – Fine | |
| | Run | 1 | | Sand - Coarse | |
| | Glide | 1 | **Rocky** | Gravel – F (2-8) | |
| | Pool | | | Gravel – M (8-16) | |
| | Backwater | 4 | | Gravel - C (16–64) | |
| **Artificial** | Canal | | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| Cover | | Water | Marginal | Riparian |
| **Aquatic** | Floating | 4 | 4 | |
| | Submerged | 4 | 4 | |
| | Emergent | 3 | 4 | |
| **Herbaceous** | Bare | | | |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | | 3 | |
| | Herbs | | | |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | | |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | |
| | Plantation | | | |

### *SITE SEM-05*

The sampling point was located in emergent and aquatic marginal vegetation at the edge of the main channel.

### Site Information

Relevant site location details.

| **Site Code:** | SEM-05 | **Date:** | 20 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.47881° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 35.07859° E | **Elevation:** | 40-60 m a.s.l. |

| Biotopes | | | | | |
|---|---|---|---|---|---|
| Hydraulic | | | Substrates | | |
| **Inundation** | Permanent | 6 | **Organic** | Leaves/Detritus | |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | |
| | Riffle | | | Sand – Fine | |
| | Run | 3 | | Sand - Coarse | |
| | Glide | 2 | **Rocky** | Gravel – F (2-8) | |
| | Pool | | | Gravel – M (8-16) | |
| | Backwater | 3 | | Gravel - C (16–64) | |
| **Artificial** | Canal | | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| Cover | | Water | Marginal | Riparian |
| **Aquatic** | Floating | 3 | 4 | |
| | Submerged | 3 | 4 | |
| | Emergent | 3 | 4 | |
| **Herbaceous** | Bare | | | |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | | 3 | |
| | Herbs | | | |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | | |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | |
| | Plantation | | | |

## *SITE SEM-06*

The sampling point was located in emergent and aquatic marginal vegetation.

### Site Information

Relevant site location details.

| **Site Code:** | SEM-06 | **Date:** | 20 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.48360° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 35.07722° E | **Elevation:** | 40-60 m a.s.l. |

| **Biotopes** | | | | | |
|---|---|---|---|---|---|
| **Hydraulic** | | | **Substrates** | | |
| **Inundation** | Permanent | 6 | **Organic** | Leaves/Detritus | |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | |
| | Riffle | | | Sand – Fine | |
| | Run | | | Sand - Coarse | |
| | Glide | 1 | **Rocky** | Gravel – F (2-8) | |
| | Pool | | | Gravel – M (8-16) | |
| | Backwater | 4 | | Gravel - C (16–64) | |
| **Artificial** | Canal | | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| Cover | | Water | Marginal | Riparian |
| **Aquatic** | Floating | 4 | 4 | |
| | Submerged | 2 | 4 | |
| | Emergent | 3 | 4 | |
| **Herbaceous** | Bare | | | |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | 2 | 2 | |
| | Herbs | | | |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | | |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | |
| | Plantation | | | |

### *SITE SEM-07*

The sampling point was located in the aquatic vegetation in clear water, at the edge of the ecotone between the clear water from a side channel and turbid waters from the Shire River.

#### Site Information

Relevant site location details.

| **Site Code:** | SEM-07 | **Date:** | 20 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.48443° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 35.07772° E | **Elevation:** | 40-60 m a.s.l. |

| Biotopes | | | | | |
|---|---|---|---|---|---|
| Hydraulic | | | Substrates | | |
| **Inundation** | Permanent | 6 | **Organic** | Leaves/Detritus | |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | |
| | Riffle | | | Sand – Fine | |
| | Run | | | Sand - Coarse | |
| | Glide | 1 | **Rocky** | Gravel – F (2-8) | |
| | Pool | | | Gravel – M (8-16) | |
| | Backwater | 4 | | Gravel - C (16–64) | |
| **Artificial** | Canal | | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| Cover | | Water | Marginal | Riparian |
| **Aquatic** | Floating | 4 | 4 | |
| | Submerged | 3 | 4 | |
| | Emergent | 4 | 4 | |
| **Herbaceous** | Bare | | | |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | 1 | 1 | |
| | Herbs | | | |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | | |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | |
| | Plantation | | | |

### *SITE SEM-08*

The sampling point was located in close proximity to SEM-07, but on the opposite side of the channel.

#### Site Information

Relevant site location details.

| Site Code: | SEM-08 | Date: | 20 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.48447° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 35.07851° E | **Elevation:** | 40-60 m a.s.l. |

| Biotopes | | | | | |
|---|---|---|---|---|---|
| Hydraulic | | | Substrates | | |
| **Inundation** | Permanent | 6 | **Organic** | Leaves/Detritus | |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | |
| | Riffle | | | Sand – Fine | |
| | Run | | | Sand - Coarse | |
| | Glide | 1 | **Rocky** | Gravel – F (2-8) | |
| | Pool | | | Gravel – M (8-16) | |
| | Backwater | 4 | | Gravel - C (16–64) | |
| **Artificial** | Canal | | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| Cover | | Water | Marginal | Riparian |
| **Aquatic** | Floating | 3 | 4 | |
| | Submerged | 3 | 4 | |
| | Emergent | 4 | 4 | |
| **Herbaceous** | Bare | | | |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | 1 | 1 | |
| | Herbs | | | |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | | |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | |
| | Plantation | | | |

### *SITE SEM-09*

The sampling point was located in marginal vegetation with slightly better water clarity (20 cm).

#### Site Information

Relevant site location details.

| **Site Code:** | SEM-09 | **Date:** | 20 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.51754° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 35.11349° E | **Elevation:** | 40-60 m a.s.l. |

| Biotopes | | | | | |
|---|---|---|---|---|---|
| Hydraulic | | | Substrates | | |
| **Inundation** | Permanent | 6 | **Organic** | Leaves/Detritus | |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | |
| | Riffle | | | Sand – Fine | |
| | Run | | | Sand - Coarse | |
| | Glide | 1 | **Rocky** | Gravel – F (2-8) | |
| | Pool | | | Gravel – M (8-16) | |
| | Backwater | 4 | | Gravel - C (16–64) | |
| **Artificial** | Canal | | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| Cover | | Water | Marginal | Riparian |
| **Aquatic** | Floating | 4 | 4 | |
| | Submerged | 4 | 4 | |
| | Emergent | 4 | 4 | |
| **Herbaceous** | Bare | | | |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | 1 | 2 | |
| | Herbs | | | |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | | |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | |
| | Plantation | | | |

### *SITE SEM-10*

The sampling point was located in aquatic vegetation.

**Site Information**

Relevant site location details.

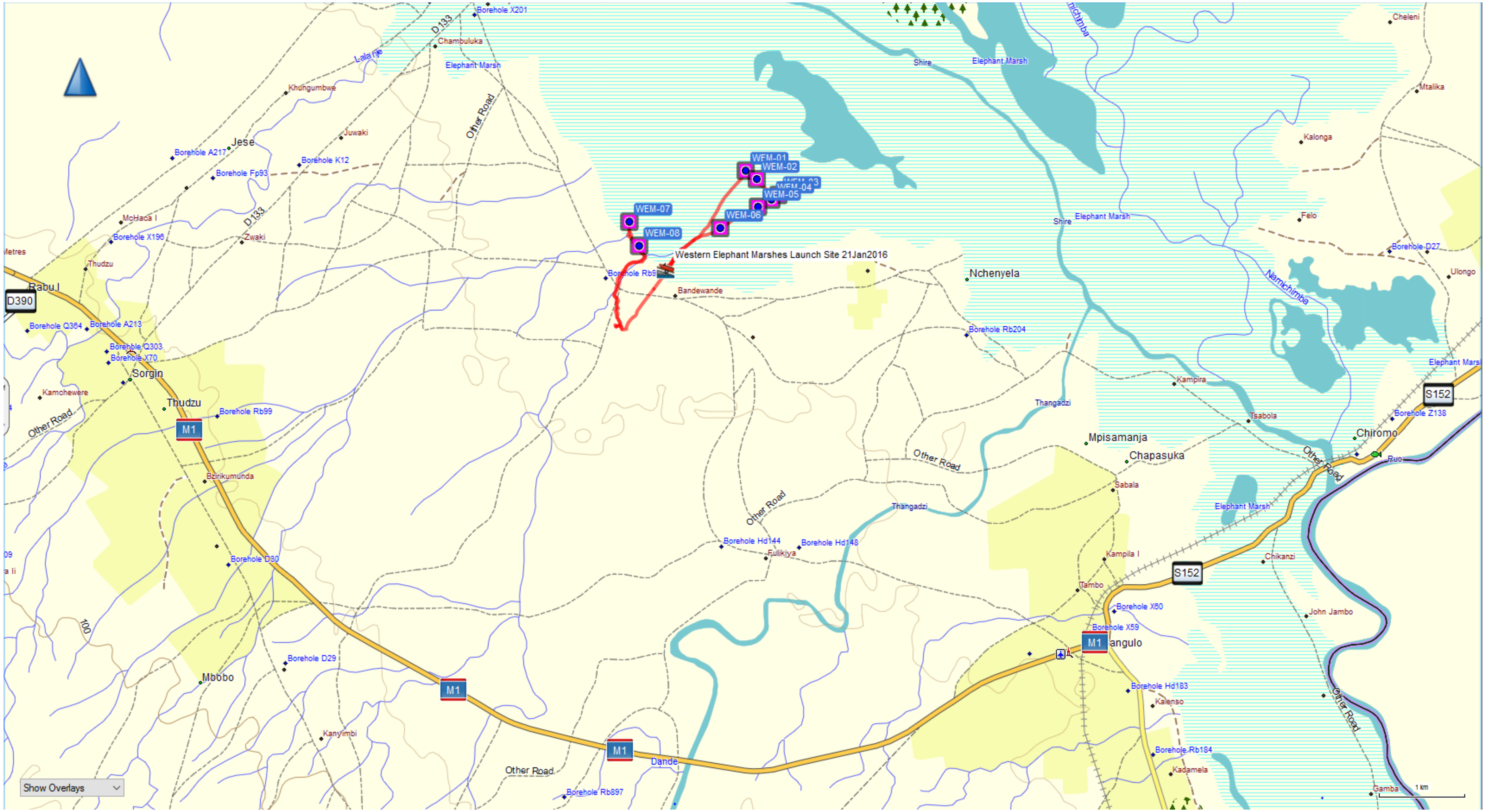
| **Site Code:** | SEM-10 | **Date:** | 20 January 2016 |
|---|---|---|---|
| **LOCATION** | | | |
| **World Aquatic Ecoregion:** | | 562: Mulanje | |
| **Latitude:** | -16.54046° S | **Catchment:** | Shire-Zambezi |
| **Longitude:** | 35.13203° E | **Elevation:** | 40-60 m a.s.l. |

| **Biotopes** | | | | | |
|---|---|---|---|---|---|
| **Hydraulic** | | | **Substrates** | | |
| **Inundation** | Permanent | 6 | **Organic** | Leaves/Detritus | |
| | Seasonal | | | Organic | |
| | Intermittent | | | Peat | |
| | Unknown | | **Mineral Soils** | Salt | |
| **Hydraulics** | Waterfall | | | Clay | |
| | Cascade | | | Loam | |
| | Rapid | | | Silt | |
| | Riffle | | | Sand – Fine | |
| | Run | 1 | | Sand - Coarse | |
| | Glide | 2 | **Rocky** | Gravel – F (2-8) | |
| | Pool | | | Gravel – M (8-16) | |
| | Backwater | 3 | | Gravel - C (16–64) | |
| **Artificial** | Canal | | | Cobble – Small (64-128) | |
| | Dam (in-channel) | | | Cobble – Large (128-250) | |
| | Dam (off-channel) | | | Boulder – Small (250-500) | |
| | Excavation | | | Boulder – Med (500-1000) | |
| | Salt Works | | | Boulder – Large (1000-4000) | |
| | Pond (e.g. WWTW) | | | Bedrock | |
| | Irrigated Land | | | Waterfall | |

| Vegetation | | | | |
|---|---|---|---|---|
| Cover | | Water | Marginal | Riparian |
| **Aquatic** | Floating | 3 | 4 | |
| | Submerged | 1 | 4 | |
| | Emergent | 4 | 4 | |
| **Herbaceous** | Bare | | | |
| | Crops | | | |
| | Geophytes | | | |
| | Grasses | 1 | 2 | |
| | Herbs | | | |
| | Invasive | | | |
| | Palmiet | | | |
| | Palms | | | |
| | Reeds | | | |
| | Restios | | | |
| | Sedges/Rushes | | | |
| **Shrubs** | Shrubs | | | |
| | Thicket | | | |
| **Trees** | Crops | | | |
| | Invasive | | | |
| | Natural | | | |
| | Plantation | | | |

## Site 5. Western Clear Water Lake

The western clear water lake is located between the NEM and SEM sites, on the western edge (WEM) of the Elephant Marsh. A canoe was launched into the water at 10h30 and returned to the launch site at 12h42, and the shallower parts of the lake were accessed by foot from 13h38 to 16h24. During this period, eight different micro-habitat sites were sampled. An insert of a topo-cadastral map indicating the location of the sampling sites. (Copied from Garmin BaseCamp Version 4.4.7, Garmap Southern Africa TOPO 2013 PRO). The photos that follow indicate some of the habitat sampled, and indicate general characteristics of the area sampled.




**Topo-cadastral map indicating the location of the sampling sites included in Site 5: Western clear water lake**

**A view of the clear water lake and a closer view of the water lily-hortwort patches of floating and submerged vegetation (S16.52584 & E35.07878; 21 January 2016).**

**Islands of submerged vegetation is extensively used by several species of water fowl (S16.52322 & E35.08093, 20 January 2016).**

**Marginal aquatic vegetation sampled in the western clear water lake (21 January 2016).**

**View of the emergent vegetation sampled dominated by *Ipomoea aquatica* (S16.52520 & E35.08325, 21 January 2016).**

**A mixture of aquatic vegetation communities which were dominated by *Ipomoea aquatica* (left) and on the right *Ludwiggia stolonifera* (S16.52624 & 35.08380, 21 January 2016).**

View of the mixed aquatic vegetation sampled which included Ludwiggia stolonifera, Pistia stratiotes, Salvinia molesta, Ipomoea aquatica and Ceratophyllum demersum (21 January 2016).

Dense stands of hornwort (Ceratophyllum demersum) with water lilies (Nymmphaea lotus) (S16.52624 & E34.08380, 21 January 2016).

**A view of the shallower portions of the lake sampled near sites WEM08 and 09 (21 January 2016).**

**View of habitat sampled at site WEM-07 (21 January 2016).**

Hydro-geomorphic unit, water quality, catchment land-use, catchment disturbance and habitat integrity are summarised for all seven of the sampled sites in the western clear water lake portion (WEM) of the Elephant Marsh because the change in land-use between the sites was considered insignificant. Results are presented in the four tables that follows.

| Hydro-geomorphic Unit | | |
|---|---|---|
| **Unit** | **Type** | **Landform** |
| Lake-Floodplain | Floodplain-Flat | Floodplain |

*In situ* measurements were only taken at one site (WEM-05), since the canoe was too unstable.

| Water Quality | | | | | |
|---|---|---|---|---|---|
| **Salinity** | Fresh (<500 mS/m) | **29.5** | **Temperature** | °C | **30.8** |
| | Brackish (500-3000 mS/m) | | **Dissolved Oxygen** | mg/ℓ | **9.35** |
| | Saline (3000-8000 mS/m) | | | % | **145.5** |
| | Hypersaline (>8000 mS/m) | | **Conductivity** | ∓S/cm | **295** |
| **pH** | Acidic (<6) | | **Water Clarity** | cm | **>120** |
| | Circum-neutral (6-8) | **8.7** | | | |
| | Alkaline (>8) | | | | |

**Catchment Land-use**

A summary of catchment land-use likely to affect surface waters at sites WEM-01 to 07.

| **Land-use** | **(0-6)** |
|---|---|
| Conservation/Wilderness | |
| Livestock - Grazing | 6 |
| Mining - Underground | |
| Forestry | |
| Recreation | 2 |
| Cultivation - Dryland | 3 |
| Cultivation - Irrigated | 4 |
| Residential - Rural | 3 |
| Residential - Urban | |
| Commercial | |
| Industrial - Light | |
| Industrial - Heavy | |
| Livestock - Feedlots | 4 |
| Mining - Open | |
| Other | |

### Catchment Disturbance

A summary of catchment disturbances at sites WEM-01 to 7, rated from natural to critical.

| | *Natural* | | | | | *Critical* |
|---|---|---|---|---|---|---|
| **Parameter** | **Zero** | **VL** | **Low** | **Mod** | **High** | **VH** |
| Catchment | | | | x | | |
| Roads/Bridges/Culverts | | | | x | | |
| Impoundments/Weirs | | | | x | | |
| Livestock | | | | | x | |
| Fire | | | | | | |
| Sewage Fungus | | | | | | |
| Algae - Benthic | | | | | | |
| Algae - Planktonic | | | | | | |
| Macrophytes | | | | | x | |
| Hydrocarbons | | x | | | | |
| Turbidity | | x | | | | |
| Colour | | x | | | | |
| Odour | | x | | | | |
| Temperature | | | | x | | |
| Foam | x | | | | | |
| pH | x | | | | | |
| Other | | | | | | |

### Sampling Sites

The sampling sites were located in aquatic vegetation at the edge and middle of the lake for the sites sampled from the canoe, and in shallow mud-vegetation at the edge of the lake for the sites accessed on foot.

### Site Information

Relevant site location details.

| DATE | SITE NO. | LATITUDE (S) | LONGITUDE (E) | ELEVATION (m a.s.l.) | WORLD AQUATIC ECOREGION |
|---|---|---|---|---|---|
| 21 January 2016 | WEM-01 | -16.52322 | 35.08093 | 40-60 | 562: Mulanje |
| | WEM-02 | -16.52409 | 35.08216 | | |
| | WEM-03 | -16.52575 | 35.08454 | | |
| | WEM-04 | -16.52624 | 35.08377 | | |
| | WEM-05 | -16.52698 | 35.08229 | | |
| | WEM-06 | -16.52919 | 35.07812 | | |
| | WEM-07 | -16.53201 | 35.07186 | | |
| | WEM-08 | -16.53105 | 35.06917 | | |

# B: Species lists per site

## Site 1. Nyala Park

Three locations were sampled in Nyala Park, one in a endorheic depression (NP-01), one in an impoundment flowing into a man-made water channel (NP-02), and one further downstream in the water channel (NP-03). The endorheic depression (NP-01) was not sampled with a net[12], but specimens observed were noted. Odonata adults are indicated in superscript as $^{Ad}$, and nymphs as $^{Ny}$. Abundances are indicated as follows:

- 1 = 1
- A = 2 – 10
- B = 11 - 100
- C = 100 – 1000
- D = >1000

| TAXA | NYALA PARK | | |
|---|---|---|---|
| | NP-01 | NP-02 | NP-03 |
| **PHYLUM: ARTHROPODA** | | | |
| **CLASS: MALACASTRACA** | | | |
| **ORDER: Decapoda** | | | |
| FAMILY: Athyidae | | | |
| *Cardinia nilotica* | | | |
| FAMILY: Potamonautidae | | | |
| *Potamonautes obesus* | | | A |
| **CLASS: INSECTA** | | | |
| **ORDER: Coleoptera** | | | |
| **SUBORDER: Adephaga** | | | |
| FAMILY: Gyrinidae | | | |
| *Gyrinus* sp. | | | B |
| **ORDER: Hemiptera** | | | |
| **SUBORDER: Heteroptera** | | | |
| FAMILY: Belostomatidae | | | |
| *Appasus* sp. | | | A |
| FAMILY: Corixidae | | | A |
| FAMILY: Gerridae | | | A |
| FAMILY: Hebridae | | | |
| *Hebrus* sp. | | | A |
| FAMILY: Hydrometridae | | | |
| *Hydrometra* sp. | | | 1 |
| FAMILY: Nepidae | | | |
| *Ranatra* sp. | | | 1 |
| **ORDER: Odonata** | | | |
| **SUBORDER: Anisoptera** | | | |

[12] Sampling equipment only arrived a day later due to misplacement of language by the airport.

| TAXA | NYALA PARK | | |
|---|---|---|---|
| | NP-01 | NP-02 | NP-03 |
| FAMILY: Aeshnidae | | | |
| *Anax* sp. | | | 1^Ny |
| *Anax tristis* | | 1^Ad | |
| FAMILY: Gomphidae | | | |
| *Gomphidia* sp21F[13]. | | | 1^Ny |
| *Paragomphus* sp. | | | |
| FAMILY: Libellulidae | | | |
| *Brachythemis leucosticta* | B^Ad | A^Ad | A^Ad |
| *Olpogastra lugubris* | | | A^Ad/Ny |
| *Orthetrum* sp. | | | 1^nY |
| *Orthetrum chrysostigma* | | | 1^Ad |
| *Orthetrum stemmale* | | 1^Ad | |
| *Pantala flavescens* | A^Ad | | |
| *Trithemis annulata* | | | A^Ad |
| **SUBORDER: Zygoptera** | | | |
| FAMILY: Coenagrionidae | | | |
| *Ischnura senegalensis* | | B^Ad | A^Ad |
| *Pseudagrion* sp. | | | A^Ny |
| *Pseudagrion* (B) *acaciae* | | | A^Ad |
| *Pseudagrion* (B) *coeleste* | | | B^Ad |
| *Pseudagrion* (B) *hamoni* | | | A^Ad |
| *Pseudagrion* (B) *massaicum* | | | A^Ad |
| FAMILY: Platycnemididae | | | |
| *Elattoneura glauca* | | | A^Ad |
| **PHYLUM: MOLLUSCA** | | | |
| **CLASS: BIVALVIA** | | | |
| FAMILY: Iridinidae | | | |
| *Chambardia wahlbergi* | B | B | |
| **CLASS: GASTROPODA** | | | |
| FAMILY: Ampullariidae | | | |
| *Lanistes ovum* | B | A | B |
| FAMILY: Thiaridae | | | |
| *Cleopatra* sp. | B | B | B |
| *Melanoides* sp. | | | B |

[13] Based on distribution (Dijkstra & Clausnitzer 2014), it is more than likely *G. quarrei*.

***Melanoides sp.*** **recorded in the flowing man-made channel at Nyala Park (NP-03) (17 January 2016).**

**Thiaridae: *Cleopatra* sp., recorded in the flowing man-made channel at Nyala Park (NP-03) (18 January 2016).**

**Nymph of *Olpogastra lugubris* recorded in the soft mud under aquatic grasses in the man-made channel at Nyala Park, NR-03 (18 January 2016).**

**Nymph of an *Orthetrum* species recorded in the mud-silt of the man-made channel at Nyala Park, NR-03 (18 January 2016).**

**Nymph of Gomphidia species (more than likely G. quarrei) recorded in the soft mud in the man-made channel at Nyala Park, NR-03 (18 January 2016).**

## Site 2. West-flowing tributaries

Four river sites (RV) were sampled using the SASS5 method. Odonata adults are indicated in superscript as $^{Ad}$, and nymphs as $^{Ny}$.

| TAXA | SITES | | | | NOTES |
|---|---|---|---|---|---|
| | RV-01 | RV-02 | RV-03 | RV-04 | |
| **PHYLUM: ARTHROPODA** | | | | | |
| **CLASS: INSECTA** | | | | | |
| **ORDER: Coleoptera** | | | | | |
| FAMILY: Gyrinidae | | | | | |
| *Dineutus* sp. | | | 1 | B | |
| FAMILY: Hydrophilidae | | | | 1 | |
| FAMILY: Noteridae | | | | | |
| *Hydrocanthus/Canthydrus* sp. | B | | | | |
| **ORDER: Diptera** | | | | | |
| FAMILY: Chironomidae | | | A | A | |
| FAMILY: Culicidae | | | | | |
| **ORDER: Ephemeroptera** | | | | | |
| **SUBORDER: Schistonota** | | | | | |
| FAMILY: Baetidae | B | A | 1 | A | |
| **SUBORDER: Pannota** | | | | | |
| FAMILY: Caenidae | A | A | A | A | |
| FAMILY: Tricorythidae | | | | | |
| *Tricorythus* sp. | A | | | | |
| **ORDER: Hemiptera** | | | | | |
| **SUBORDER: Heteroptera** | | | | | |
| FAMILY: Belostomatidae | | | | | |
| *Lethocerus niloticus* | | | | | |
| FAMILY: Corixidae | | A | B | | |
| *Micronecta* sp. | B | | | | |
| FAMILY: Gerridae | | | | | |
| FAMILY: Hebridae | | | | | |
| FAMILY: Hydrometridae | | | | | |
| *Hydrometra* sp. | | | | | |
| FAMILY: Naucoridae | | B | B | B | |
| *Macrocoris* sp. | B | | | | |
| FAMILY: Nepidae | | | 1 | 1 | |
| *Ranatra* sp. | | | | | |
| FAMILY: Pleidae | | | | | |
| FAMILY: Veliidae | A | A | A | A | |
| **ORDER: Odonata** | | | | | |
| **SUBORDER: Anisoptera** | | | | | |
| FAMILY: Aeshnidae | | | | | |
| *Anax* sp. | | | | | |
| *Anax tristis* | | | | | |
| FAMILY: Gomphidae | | | | | |
| *Gomphidia* sp. | | | | | |
| *Paragomphus* sp. | B | B | | B | Nymph |
| FAMILY: Libellulidae | 1 | | | | |
| *Brachythemis leucosticta* | | | | | |
| *Crocothemis erythraea* | | | | | |
| *Olpogastra lugubris* | | | | | |
| *Orthetrum* sp. | | | | | |
| *Orthetrum stemmale* | | | | | |
| *Pantala flavescens* | | | A | | Adult |
| *Tramea basilaris* | | | | | |
| *Trithemis* sp. | | | 1 | | |
| *Trithemis annulata* | | | | | |

| TAXA | SITES | | | | NOTES |
|---|---|---|---|---|---|
| | RV-01 | RV-02 | RV-03 | RV-04 | |
| **PHYLUM: ARTHROPODA** | | | | | |
| *Urothemis edwardsii* | | | | | |
| *Zygonyx torridus* | | | | | Nymph. |
| **SUBORDER: Zygoptera** | | | | | |
| FAMILY: Coenagrionidae | | A | | 1 | |
| *Ischnura senegalensis* | | | | | |
| *Pseudagrion* sp. | | 1 | | | |
| *Pseudagrion* (A) *kersteni* | | | | A | |
| *Pseudagrion* (B). *sp.* | A | | | A | |
| *Pseudagrion* (B) *acaciae* | | | | | |
| *Pseudagrion* (B) *coeleste* | | | | | |
| *Pseudagrion* (B) *hamoni* | | | | | |
| FAMILY: Platycnemididae | | | | | |
| *Elattoneura glauca* | | | | | |
| **ORDER: Trichoptera** | | | | | |
| **SUBORDER: Annulipalpia** | | | | | |
| FAMILY: Hydropsychidae | | | | | |
| *Hydropsyche longifurca??* | | | 1 | | |
| **PHYLUM: MOLLUSCA** | | | | | |
| **CLASS: BIVALVIA** | | | | | |
| FAMILY: Iridinidae | | | | | |
| *Chambardia wahlbergi* | | | | | |
| **CLASS: GASTROPODA** | | | | | |
| FAMILY: Ampullariidae | | | | | |
| *Lanistes ovum* | | | | | |
| FAMILY: Planorbidae | | | | | |
| Subfamily: Bulininae | | | | | |
| Subfamily: Planorbinae | | | | | |
| *Bulinus* sp. | | | | | |
| FAMILY: Thiaridae | | B | | | |
| *Cleopatra* sp. | | | | | |
| *Melanoides* sp. | | | | | |

## Site 3. North-western portion of the Elephant Marsh

Six sampling locations within aquatic vegetation and shallow mud-banks were sampled with a SASS5 net in the north-western portion (NEM) of the Shire River. Odonata adults are indicated in superscript as $^{Ad}$, and nymphs as $^{Ny}$.

| TAXA | SITES | | | | | |
|---|---|---|---|---|---|---|
| | NEM-01 | NEM-02 | NEM-03 | NEM-04 | NEM-05 | NEM-06 |
| **PHYLUM: ARTHROPODA** | | | | | | |
| **CLASS: MALACASTRACA** | | | | | | |
| **ORDER: Decapoda** | | | | | | |
| FAMILY: Athyidae | | | | | | |
| *Cardinia nilotica* | A | B | | | | |
| **CLASS: INSECTA** | | | | | | |
| **ORDER: Coleoptera** | | | | | | |
| **SUBORDER: Adephaga** | | | | | | |
| FAMILY: Gyrinidae | | | | | | A |
| **SUBORDER: Polyphaga** | | | | | | |
| FAMILY: Hydrochidae | | B | | | | |
| **ORDER: Ephemeroptera** | | | | | | |
| **SUBORDER: Schistonota** | | | | | | |
| FAMILY: Baetidae | A | B | B | 1 | A | A |
| FAMILY: Heptageniidae | | | | | | |
| *Afronurus* sp. | | A | | | | |
| FAMILY: Leptophlebiidae | | | 1 | | | |
| FAMILY: Oligoneuridae | | | | | | |
| *Elassoneuria* sp. | | | A | | 1 | |
| FAMILY: Polymitarcidae | | | | 1 | | |
| **SUBORDER: Pannota** | | | | | | |
| FAMILY: Caenidae | | | A | | | |
| **ORDER: Hemiptera** | | | | | | |
| **SUBORDER: Heteroptera** | | | | | | |
| FAMILY: Gerridae | | | | | | |
| FAMILY: Hebridae | | | | | | A |
| FAMILY: Hydrometridae | | | | | | |
| *Hydrometra* sp. | | 1 | | | | |
| FAMILY: Mesoveliidae | | | | | | |
| *Mesovelia* sp. | | A | | | | |
| FAMILY: Naucoridae | | | | 1 | | 1 |
| FAMILY: Nepidae | | | | | | |
| *Ranatra* sp. | | | | | | A |
| FAMILY: Veliidae | | | | | | |
| *Rhagovelia* sp. | B | | | | | |
| *Tenagovelia* sp. | | | B | | | |
| **ORDER: Odonata** | | | | | | |
| **SUBORDER: Anisoptera** | | | | | | |
| FAMILY: Gomphidae | | | | | | |
| *Crenigomphus* sp.[14] | | $A^{Ny}$ | | | | $A^{Ny}$ |
| FAMILY: Libellulidae | | | | | | |
| *Brachythemis leucosticta* | $A^{Ad}$ | | | | | |
| *Crocothemis erythraea* | $A^{Ad}$ | | | | | |

[14] Based on distribution (Dijkstra & Clausnitzer 2014) more than likely *C. hartmanni.*

| **TAXA** | **SITES** | | | | | |
|---|---|---|---|---|---|---|
| | **NEM-01** | **NEM-02** | **NEM-03** | **NEM-04** | **NEM-05** | **NEM-06** |
| **PHYLUM: ARTHROPODA** | | | | | | |
| *Pantala flavescens* | | | | | | $A^{Ad}$ |
| *Trithemis annulata* | | | | | | $A^{Ad}$ |
| **SUBORDER: Zygoptera** | | | | | | |
| FAMILY: Coenagrionidae | | | | | | A |
| *Ischnura senegalensis* | | $A^{Ad}$ | | | | |
| *Pseudagrion* sp. | $A^{Ny}$ | $B^{Ny}$ | | | | |
| *Pseudagrion* (B) sp. | | | $A^{Ny}$ | | | |
| *Pseudagrion* (B) *acaciae* | | $A^{Ad}$ | | | | |
| | | | | | | |

## Site 4. South-western portion of the Elephant Marsh

Eleven sampling points along the Shire River were sampled, with different vegetation types in different flow velocities the most dominant. Site SEM-11 was the launch site, and only the adult Odonata observed in a very short period are listed.

| TAXA | SITES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | SEM-01 | SEM-02 | SEM-03 | SEM-04 | SEM-05 | SEM-06 | SEM-07 | SEM-08 | SEM-09 | SEM-10 | SEM-11 |
| **PHYLUM: ANNELIDA** | | | | | | | | | | | |
| **CLASS: HIRUDINEA** | | | | | | | | | | | |
| FAMILIY: Glossiphoniidae | | | | | | | | | | | |
| *Alboglossiphonia* sp. | 1 | | | | | | | | | | |
| *Theromyzon* sp. | | | | | | | | 1 | | | |
| **CLASS: OLIGOCHAETA** | 1 | | | | 1 | | | | | | |
| **PHYLUM: ARTHROPODA** | | | | | | | | | | | |
| **CLASS: ARACHNIDA** | | | | | | | | | | | |
| **ORDER: Acarina** | | | | | | | A | | | A | |
| **CLASS: MALACASTRACA** | | | | | | | | | | | |
| **ORDER: Decapoda** | | | | | | | | | | | |
| FAMILY: Athyidae | | | | | | | | | | | |
| *Cardinia nilotica* | B | B | B | A | B | | | | A | B | |
| **CLASS: INSECTA** | | | | | | | | | | | |
| **ORDER: Coleoptera** | | | | | | | | | | | |
| FAMILY: Dytiscidae | B | B | B | A | B | B | B | B | | B | |
| FAMILY: Gyrinidae | | | | | A | | | | | | |
| *Gyrinus* sp. | | | B | | | | | | | | |
| FAMILY: Hydrophilidae | | 1 | | | | | A | | A | | |
| *Amphiops* sp. | | 1 | A | 1 | | | | A | | | |
| SUBFAMILY: Hydroporinae | | | | | | | A | | | | |
| **ORDER: Diptera** | | | | | | | | | | | |
| FAMILY: Chironomidae | A | A | | | A | | A | | | | |
| FAMILY: Culicidae | | | | | | | B | | | | |
| *Anopheles* sp. | | | | | | | A | A | | | |
| *Culex* sp. | | | | | | | A | | | | |
| **ORDER: Ephemeroptera** | | | | | | | | | | | |
| **SUBORDER: Schistonota** | | | | | | | | | | | |

| TAXA | SITES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **SEM-01** | **SEM-02** | **SEM-03** | **SEM-04** | **SEM-05** | **SEM-06** | **SEM-07** | **SEM-08** | **SEM-09** | **SEM-10** | **SEM-11** |
| FAMILY: Baetidae | A | A | A | B | B | A | B | 1 | B | | |
| FAMILY: Heptageniidae | | | | | | | | | | | |
| FAMILY: Leptophlebiidae | | | | A | | | | | | | |
| FAMILY: Oligoneuridae | | | | | | | | | | | |
| FAMILY: Polymitarcidae | | | | | | | | | | | |
| **SUBORDER: Pannota** | | | | | | | | | | | |
| FAMILY: Caenidae | B | A | A | A | A | | A | B | B | | |
| **ORDER: Hemiptera** | | | | | | | | | | | |
| **SUBORDER: Heteroptera** | | | | | | | | | | | |
| FAMILY: Belostomatidae | 1 | A | | | | 1 | A | | A | A | |
| *Appasus* sp. | | | | 1 | | | | | | | |
| *Lethocerus niloticus* | | 1 | | | | | | | | | |
| FAMILY: Corixidae | | | | | | A | A | A | A | B | |
| FAMILY: Gerridae | | | | B | B | | A | | | | |
| FAMILY: Hebridae | | | | | | | | | | | |
| FAMILY: Hydrometridae | | | | | | | | | | | |
| *Hydrometra* sp. | | | | | | | | | | 1 | |
| FAMILY: Naucoridae | A | | | | | A | A | | 1 | A | |
| *Naucoris* sp. | | | | A | | | | | | | |
| FAMILY: Nepidae | | | | | | | | | | | |
| *Ranatra* sp. | | | | | | | | | | | |
| FAMILY: Notonectidae | | | | | | | | | | | |
| *Nychia limpida* | | | | | | | A | | | | |
| FAMILY: Pleidae | | | | | | A | | | | | |
| FAMILY: Veliidae | | | A | A | | | A | | 1 | | |
| *Rhagovelia* sp. | B | | | | | | | | | | |
| **ORDER: Odonata** | | | | | | | | | | | |
| **SUBORDER: Anisoptera** | | | | | | | | | | | |
| FAMILY: Gomphidae | | | | | | | | | | | |
| *Ictinogomphus ferox* | | | | | $1^{Ad}$ | | | | | | |
| *Paragomphus* sp. | | | | | | | | | | | |
| FAMILY: Libellulidae | | B | | A | | A | B | B | | B | |
| *Aethriamantha rezia* | $B^{Ny}$ | $A^{Ny}$ | | $B^{Ny}$ | | | $A^{Ny}$ | | | | |
| *Brachythemis leucosticta* | | | | | | | | | | | |
| *Crocothemis erythraea* | | | | | | | | | | | |
| *Pantala flavescens* | | | | | | | | | | | |

| **TAXA** | **SITES** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **SEM-01** | **SEM-02** | **SEM-03** | **SEM-04** | **SEM-05** | **SEM-06** | **SEM-07** | **SEM-08** | **SEM-09** | **SEM-10** | **SEM-11** |
| *Tramea basilaris* | | | | | | | | | | | $B^{Ad}$ |
| *Trithemis* sp. | $1^{Ny}$ | | | | | | | | | | |
| *Trithemis annulata* | | | | | | | | | | | |
| *Urothemis edwardsii* | | | | | | | | | | | $A^{Ad}$ |
| **SUBORDER: Zygoptera** | | | | | | | | | | | |
| FAMILY: Coenagrionidae | A | B | A | | | 1 | | A | A | A | |
| *Agriocnemis* sp. | | | | | | | | $1^{Ny}$ | | | |
| *Ischnura senegalensis* | | | | | $A^{Ad}$ | | | | | | |
| *Pseudagrion* sp. | | | | $B^{Ny}$ | | | | | | | |
| *Pseudagrion* (B) *acaciae* | | | | | $A^{Ad}$ | | | | | | |
| **ORDER: Trichoptera** | | | | | | | | | | | |
| **PHYLUM: MOLLUSCA** | | | | | | | | | | | |
| **CLASS: GASTROPODA** | | | | | | | | | | | |
| FAMILY: Planorbidae | | | | | | | | | | | |
| Subfamily: Bulininae | | A | | | | | | | | | |
| Subfamily: Planorbinae | 1 | B | | | | C | B | | | | |
| *Bulinus* sp. | | A | A | | | A | | A | | | |
| FAMILY: Succineidae | | | | | | | | | | | |
| *Oxyloma* sp. | | | | | | | 1 | | | | |
| FAMILY: Thiaridae | | | | | | | A | | | | |
| **PHYLUM: PLATYHELMINTHES** | | | | | | | | | | | |
| **CLASS: TURBELLARIA** | | | | | | | | | | 1 | |

## Site 5. Western portion of the Elephant Marsh

Water clarity in this portion of the Elephant Marsh was measured as >120 cm (21/01/2016), compared to the 2 cm at sites located in the in the northern portion (NEM) and 5 to 20 cm in the lower portion (SEM), both in the main channel.

| TAXA | SITES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | WEM-01 | WEM-02 | WEM-03 | WEM-04 | WEM-05 | WEM-06 | WEM-07 | WEM-08 | WEM-09 |
| **PHYLUM: ANNELIDA** | | | | | | | | | |
| **CLASS: HIRUDINEA** | | | | | | | | | |
| **CLASS: OLIGOCHAETA** | | A | A | 1 | | | | | |
| **PHYLUM: ARTHROPODA** | | | | | | | | | |
| **CLASS: ARACHNIDA** | | | | | | | | | |
| **ORDER: Acarina** | | A | | 1 | | A | | | |
| **CLASS: MALACASTRACA** | | | | | | | | | |
| **ORDER: Decapoda** | | | | | | | | | |
| FAMILY: Athyidae | | | | | | | | | |
| *Cardinia nilotica* | | | | B | | | | | |
| **ORDER: Isopoda** | | | | | | | | | |
| FAMILY: Porcellionidae | | | | | | | B | B | |
| **CLASS: INSECTA** | | | | | | | | | |
| **ORDER: Coleoptera** | | | | | | | | | |
| FAMILY: Dytiscidae | B | B | B | A | | | | B | |
| FAMILY: Gyrinidae | A | | | | | | | | |
| *Dineutus* sp. | | | | | | | | | |
| FAMILY: Hydrophilidae | B | A | | | | | A | A | |
| *Amphiops* sp. | A | | 1 | | | | | | |
| *Hydrophilus* sp. | | | | | | | 1 | A | |
| FAMILY: Noteridae | | | | | | | | | |
| *Hydrocanthus/Canthydrus* sp. | | | | | | | | | |
| **ORDER: Diptera** | | | | | | | | | |
| **SUBORDER: Brachycera** | | | | | | | | | |
| FAMILY: Tabanidae | | | 1 | | | | | | |

| TAXA | SITES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | WEM-01 | WEM-02 | WEM-03 | WEM-04 | WEM-05 | WEM-06 | WEM-07 | WEM-08 | WEM-09 |
| FAMILY: Stratiomyidae | | | A | | | | | | |
| **SUBORDER: Nematocera** | | | | | | | | | |
| FAMILY: Chironomidae | | | | | | | | | |
| FAMILY: Culicidae | A | A | | | | | | | |
| *Uranotaenia* sp. | | | A | | | | | | |
| FAMILY: Psycodidae | | | B | | | | | | |
| **ORDER: Ephemeroptera** | | | | | | | | | |
| **SUBORDER: Schistonota** | | | | | | | | | |
| FAMILY: Baetidae | A | | 1 | | | | | | |
| FAMILY: Heptageniidae | | | | | | | | | |
| FAMILY: Leptophlebiidae | | | | | | | | | |
| FAMILY: Oligoneuridae | | | | | | | | | |
| FAMILY: Polymitarcidae | | | | | | | | | |
| **SUBORDER: Pannota** | | | | | | | | | |
| FAMILY: Caenidae | | | | | | | | | |
| FAMILY: Tricorythidae | | | | | | | | | |
| *Tricorythus* sp. | | | | | | | | | |
| **ORDER: Hemiptera** | | | | | | | | | |
| **SUBORDER: Heteroptera** | | | | | | | | | |
| FAMILY: Belostomatidae | | A | | | | | | | |
| *Appasus* sp. | | | A | | | | | | |
| *Lethocerus niloticus* | | | | | | | | | |
| *Limnogeton* sp. | B | | | | | | | | |
| FAMILY: Corixidae | A | | | B | | | | C | |
| *Micronecta* sp. | | | | | | | | | |
| FAMILY: Gerridae | | | | | | | | | |
| FAMILY: Hebridae | | | | | | | | | |
| FAMILY: Hydrometridae | | | | | | | | | |
| *Hydrometra* sp. | | | | | | | | | |
| FAMILY: Mesoveliidae | | | | | | | | | |

| TAXA | SITES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | WEM-01 | WEM-02 | WEM-03 | WEM-04 | WEM-05 | WEM-06 | WEM-07 | WEM-08 | WEM-09 |
| *Mesovelia* sp. | | | A | | | | | | |
| FAMILY: Naucoridae | | | | | | | | | |
| *Macrocoris* sp. | | | | | | | | | |
| *Naucoris* sp. | | A | A | | | A | | | |
| FAMILY: Nepidae | | | | | | | | | |
| *Ranatra* sp. | | | | | | | | | |
| FAMILY: Notonectidae | A | | | | | | | | |
| FAMILY: Parahrynoveliidae | | | | | | | | | |
| *Paraphrynovelia* sp. | | A | | | | | | | |
| FAMILY: Pleidae | | | | | | | | | |
| *Plea* sp. | A | | A | A | | | | | |
| FAMILY: Veliidae | B | B | A | | | | | | |
| **ORDER: Odonata** | | | | | | | | | |
| **SUBORDER: Anisoptera** | | | | | | | | | |
| FAMILY: Aeshnidae | | | | | | | | | |
| *Anax* sp. | | | | | | | | | |
| *Anax tristis* | | | | | | | | | |
| FAMILY: Gomphidae | | | | | | | | | |
| *Gomphidia* sp. | | | | | | | | | |
| *Ictinogomphus ferox* | | | | | | | | | A[Ad] |
| *Paragomphus* sp. | | | | | | | | | |
| FAMILY: Libellulidae | B | A | 1 | | | | | | |
| *Brachythemis leucosticta* | | | | | | | | | C[Ad] |
| *Crocothemis erythraea* | | | | | | | | | B[Ad] |
| *Diplacodes lefebvrii* | | | | | | | | | C[Ad] |
| *Olpogastra lugubris* | | | | | | | | | |
| *Orthetrum* sp. | | | | | | | | | |
| *Orthetrum stemmale* | | | | | | | | | |
| *Orthetrum trinacria* | | | | | | | | | A[Ad] |
| *Pantala flavescens* | | | | | | | | | B[Ad] |

| TAXA | SITES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | WEM-01 | WEM-02 | WEM-03 | WEM-04 | WEM-05 | WEM-06 | WEM-07 | WEM-08 | WEM-09 |
| *Rhyothemis semihyalina* | | | | | | | | | $A^{Ad}$ |
| *Tramea basilaris* | | | | | | | | | |
| *Trithemis* sp. | | | | | | | | | |
| *Trithemis annulata* | | | | | | | | | |
| *Urothemis edwardsii* | | | | | | | | | $C^{Ad}$ |
| *Zygonyx torridus* | | | | | | | | | |
| **SUBORDER: Zygoptera** | | | | | | | | | |
| FAMILY: Coenagrionidae | | | 1 | A | | | | | |
| *Ischnura senegalensis* | | | | | | | | | $C^{Ad}$ |
| *Pseudagrion* sp. | | | | | | | | | |
| *Pseudagrion* (A) *kersteni* | | | | | | | | | |
| *Pseudagrion* (B). *sp.* | | | | | | | | | |
| *Pseudagrion* (B) *acaciae* | | | | | | | | | |
| *Pseudagrion* (B) *coeleste* | | | | | | | | | |
| *Pseudagrion* (B) *hamoni* | | | | | | | | | |
| *Pseudagrion* (B) *massaicum* | | | | | | | | | $C^{Ad}$ |
| FAMILY: Platycnemididae | | | | | | | | | |
| *Elattoneura glauca* | | | | | | | | | |
| **ORDER: Trichoptera** | | | | | | | | | |
| **SUBORDER: Annulipalpia** | | | | | | | | | |
| FAMILY: Hydropsychidae | | | | | | | | | |
| **PHYLUM: MOLLUSCA** | | | | | | | | | |
| **CLASS: BIVALVIA** | | | | | | | | | |
| FAMILY: Iridinidae | | | | | | | | | |
| *Chambardia wahlbergi* | | | | | | | | | |
| **CLASS: GASTROPODA** | | | | | | | | | |
| FAMILY: Ampullariidae | | | | | | | | | |
| *Lanistes ovum* | | | | B | | | | | |
| FAMILY: Planorbidae | | | | | | | | | |
| Subfamily: Bulininae | | A | | A | | | | | |

| TAXA | SITES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | WEM-01 | WEM-02 | WEM-03 | WEM-04 | WEM-05 | WEM-06 | WEM-07 | WEM-08 | WEM-09 |
| Subfamily: Planorbinae | | C | C | | | | | | |
| *Bulinus* sp. | B | | | | | A | | | |
| *Bulinus forskalii* | | | B | B | | | | | |
| FAMILY: Thiaridae | 1 | A | | | | | | C | |
| *Cleopatra* sp. | | | | | | | | | |
| *Melanoides* sp. | | | | | | | | | |
| **PHYLUM: PLATYHELMINTHES** | | | | | | | | | |
| **CLASS: TURBELLARIA** | | | | | | | | | |

## Summary

A brief summary of taxa recorded at the different areas sampled are shown in the table below. The three sites in Nyala Park (NP) are combined, the four sites on west-flowing tributaries (WFT), the six sites in the north-western portion of the marshes (NEM), and the nine sites on the western portion of the Elephant Marshes between the villages Thudzu and Nchenyela are combined. Odonata adults were surveyed by Klaas-Douwe Dijkstra (KD) in March 2016, but notes of specimens encountered were also made in this survey, January 2016. Note that “Ny” refers to nymphs, and “Ad” to adults.

| TAXA | AREAS | | | | | | |
|---|---|---|---|---|---|---|---|
| | NP | WFT | Shire River | | | | ALL |
| | | | NEM | SEM | WEM | All | |
| **PHYLUM: ANNELIDA** | | | | | | | |
| **CLASS: HIRUDINEA** | | | | | | | |
| FAMILY: Glossiphoniidae | | | | | | | |
| *Alboglossiphoniidae* sp. | | | | 1 | | **x** | **Jan** |
| *Theromyzon* sp. | | | | 1 | | **x** | **Jan** |
| **CLASS: OLIGOCHAETA** | | | | A | B | **x** | **Jan** |
| **PHYLUM: ARTHROPODA** | | | | | | | |
| **CLASS: ARACHNIDA** | | | | | | | |
| **ORDER: Acarina** | | | | A | B | **x** | **Jan** |
| **CLASS: MALACASTRACA** | | | | | | | |
| **ORDER: Decapoda** | | | | | | | |
| FAMILY: Athyidae | | | | | | | |
| *Cardinia nilotica* | | | B | C | B | **x** | **Jan** |
| FAMILY: Athyidae | | | | | | | |
| *Potamonautes obesus* | **A** | | | | | | **Jan** |
| **ORDER: Isopoda** | | | | | | | |
| FAMILY: Porcellionidae | | | | | B | **x** | **Jan** |
| **CLASS: INSECTA** | | | | | | | |
| **ORDER: Coleoptera** | | | | | | | |
| **SUBORDER: Adephaga** | | | | | | | |
| FAMILY: Dytiscidae | | | | C | C | **x** | **Jan** |
| SUBFAMILY: Hydroporinae | | | | A | | **x** | **Jan** |
| FAMILY: Gyrinidae | | | A | B | A | **x** | **Jan** |
| *Dineutus* sp. | | **B** | | | | | **Jan** |
| *Gyrinus* sp. | | **B** | | | | | **Jan** |
| FAMILY: Noteridae | | | | | | | |
| *Hydrocanthus/Canthydrus* sp. | | **B** | | | | | **Jan** |
| **SUBORDER: Polyphaga** | | | | | | | |
| FAMILY: Hydrochidae | | | B | | | **x** | **Jan** |
| FAMILY: Hydrophilidae | | **1** | | B | B | **x** | **Jan** |
| *Amphiops* sp. | | | | A | A | **x** | **Jan** |
| *Hydrophilus* sp. | | | | | A | **x** | **Jan** |
| FAMILY: Staphylinidae | | | | | | | |
| *Stenus* sp. | | | | | A | **x** | **Jan** |
| **ORDER: Diptera** | | | | | | | |
| **SUBORDER: Brachycera** | | | | | | | |

| TAXA | AREAS | | | | | | |
|---|---|---|---|---|---|---|---|
| | NP | WFT | Shire River | | | | ALL |
| | | | NEM | SEM | WEM | All | |
| FAMILY: Tabanidae | | | | | 1 | **x** | **Jan** |
| FAMILY: Stratiomyidae | | | | | A | **x** | **Jan** |
| **SUBORDER: Nematocera** | | | | | | | |
| FAMILY: Chironomidae | | **A** | | B | | **x** | **Jan** |
| FAMILY: Culicidae | | | | B | B | **x** | **Jan** |
| *Anopheles* sp. | | | | B | | **x** | **Jan** |
| *Culex* sp. | | | | A | | | **Jan** |
| FAMILY: Psycodidae | | | | | B | **x** | **Jan** |
| **ORDER: Ephemeroptera** | | | | | | | |
| **SUBORDER: Schistonota** | | | | | | | |
| FAMILY: Baetidae | | **C** | C | C | 1 | **x** | **Jan** |
| FAMILY: Heptageniidae | | | | | | | |
| *Afronurus* sp. | | | A | | | **x** | **Jan** |
| FAMILY: Leptophlebiidae | | | 1 | A | | **x** | **Jan** |
| FAMILY: Oligoneuridae | | | | | | | |
| *Elassoneuria* sp. | | | A | | | **x** | **Jan** |
| FAMILY: Polymitarcidae | | | | | | | |
| *Ephron* sp. | | | 1 | | | **x** | **Jan** |
| **SUBORDER: Pannota** | | | | | | | |
| FAMILY: Caenidae | | **B** | A | C | | **x** | **Jan** |
| FAMILY: Tricorythidae | | | | | | | |
| *Tricorythus* sp. | | **A** | | | | | **Jan** |
| **ORDER: Hemiptera** | | | | | | | |
| **SUBORDER: Heteroptera** | | | | | | | |
| FAMILY: Belostomatidae | | | | B | A | **x** | **Jan** |
| *Appasus* sp. | | | | 1 | A | **x** | **Jan** |
| *Lethocerus niloticus* | | | | 1 | | **x** | **Jan** |
| *Limnogeton* sp. | | | | | B | **x** | **Jan** |
| FAMILY: Corixidae | **A** | **B** | | B | C | **x** | **Jan** |
| *Micronecta* sp. | | **B** | | | | | **Jan** |
| FAMILY: Gerridae | **A** | | | C | | **x** | **Jan** |
| FAMILY: Hebridae | **A** | | A | | | **x** | **Jan** |
| FAMILY: Hydrometridae | | | | | | | |
| *Hydrometra* sp. | **1** | | 1 | 1 | | **x** | **Jan** |
| FAMILY: Mesoveliidae | | | | | | | |
| *Mesovelia* sp. | | | A | | A | **x** | **Jan** |
| FAMILY: Naucoridae | | **B** | A | B | | **x** | **Jan** |
| *Macrocoris* sp. | | **B** | | | | | **Jan** |
| *Naucoris* sp. | | | | A | B | **x** | **Jan** |
| FAMILY: Nepidae | | **A** | | | | | **Jan** |
| *Ranatra* sp. | **1** | | A | | | **x** | **Jan** |
| FAMILY: Notonectidae | | | | | A | **x** | **Jan** |
| *Nychia limpida* | | | A | | | | **Jan** |
| FAMILY: Paraphrynoveliidae | | | | | | | |
| *Paraphrynovelia* sp. | | **A** | | | | | **Jan** |
| FAMILY: Pleidae | | | | | | | |
| *Plea* sp. | | | | A | B | **x** | **Jan** |

| TAXA | AREAS | | | | | | |
|---|---|---|---|---|---|---|---|
| | NP | WFT | Shire River | | | | ALL |
| | | | NEM | SEM | WEM | All | |
| FAMILY: Veliidae | | **A** | | B | B | **x** | **Jan** |
| *Rhagovelia* sp. | | | B | | | | |
| *Tenagovelia* sp. | | | B | | | **x** | **Jan** |
| **ORDER: Odonata** | | | | | | | |
| **SUBORDER: Anisoptera** | | | | | | | |
| FAMILY: Aeshnidae | | | | | | | |
| *Anax* sp. | $1^{Ny}$ | | | | | | **Jan** |
| *Anax imperator* | | | | | | **KD** | **Mar** |
| *Anax tristis* | $1^{Ad}$ | | | | | | **Jan** |
| FAMILY: Gomphidae | | | | | | | |
| *Crenigomphus* sp. | | | $A^{Ny}$ | | | | |
| *Gomphidia* sp. | $1^{Ny}$ | | | | | | **Jan** |
| *Ictinogomphus ferox* | **KD** | | | $1^{Ad}$ | $A^{Ad}$ | **KD** | **Jan/Mar** |
| *Paragomphus* sp. | | $B^{Ny}$ | | | | | |
| FAMILY: Libellulidae | | $1^{Ny}$ | | $C^{Ny}$ | $B^{Ny}$ | | |
| *Acisoma variegatum* | **KD** | | | | | **KD** | **Mar** |
| *Aethriamantha rezia* | | | | $C^{Ad/Ny}$ | | **KD** | **Jan/Mar** |
| *Brachythemis leucosticta* | $B^{Ad}$/**KD** | | $A^{Ad}$ | | $C^{Ad}$ | **KD** | **Jan/Mar** |
| *Crocothemis erythraea* | **KD** | | $A^{Ad}$ | | $B^{Ad}$ | **KD** | **Jan/Mar** |
| *Diplacodes lefebvrii* | **KD** | | | | $C^{Ad}$ | **KD** | **Jan/Mar** |
| *Diplacodes luminans* | **KD** | | | | | | **Mar** |
| *Hemistigma albipunctum* | **KD** | | | | | | **Mar** |
| *Nesciothemis farinosa* | **KD** | | | | | | **Mar** |
| *Olpogastra lugubris* | $A^{Ad/Ny}$ | | | | | | **Jan** |
| *Orthetrum* sp. | $1^{Ny}$ | | | | | | **Jan** |
| *Orthetrum brachiale* | **KD** | | | | | | **Mar** |
| *Orthetrum chrysostigma* | $1^{Ad}$ | | | | | | **Jan** |
| *Orthetrum stemmale* | $A^{Ad}$/**KD** | | | | | | **Jan/Mar** |
| *Orthetrum trinacria* | **KD** | | | | $A^{Ad}$ | **KD** | **Jan/Mar** |
| *Pantala flavescens* | $A^{Ad}$/**KD** | $A^{Ad}$ | $A^{Ad}$ | | $B^{Ad}$ | **KD** | **Jan/Mar** |
| *Rhyothemis semihyalina* | | | | | $A^{Ad}$ | **KD** | **Jan/Mar** |
| *Tholymis tillarga* | **KD** | | | | | | **Mar** |
| *Tramea basilaris* | | | | $B^{Ad}$ | | | **Jan** |
| *Trithemis* sp. | | $1^{Ny}$ | | $1^{Ny}$ | | | **Jan** |
| *Trithemis annulata* | $A^{Ad}$/**KD** | | $A^{Ad}$ | | | **KD** | **Jan/Mar** |
| *Urothemis assignata* | **KD** | | | | | **KD** | **Jan/Mar** |
| *Urothemis edwardsii* | | | | $A^{Ad}$ | $C^{Ad}$ | **KD** | **Jan/Mar** |
| *Zygonyx torridus* | | | | | | | |
| **SUBORDER: Zygoptera** | | | | | | | |
| FAMILY: Coenagrionidae | | $A^{Ny}$ | $A^{Ny}$ | $B^{Ny}$ | $A^{Ny}$ | | |
| *Agriocnemis* sp. | | | | $1^{Ny}$ | | | **Jan** |
| *Agriocnemis gracile* | **KD** | | | | | | **Mar** |
| *Ceriagrion glabrum* | $A^{Ad}$/**KD** | | $A^{Ad}$ | $A^{Ad}$ | $A^{Ad}$ | $A^{Ad}$/**KD** | **Jan/Mar** |
| *Ceriagrion kordofanicum* | | | | | | **KD** | **Mar** |
| *Ischnura senegalensis* | $A^{Ad}$/**KD** | | $A^{Ad}$ | $A^{Ad}$ | $C^{Ad}$ | $C^{Ad}$/**KD** | **Jan/Mar** |
| *Pseudagrion* sp. | | $1^{Ny}$ | $B^{Ny}$ | $B^{Ny}$ | | | **Jan** |
| *Pseudagrion* (A) *kersteni* | | $A^{Ad}$ | | | | | **Jan** |

| TAXA | AREAS | | | | | | |
|---|---|---|---|---|---|---|---|
| | NP | WFT | Shire River | | | | ALL |
| | | | NEM | SEM | WEM | All | |
| *Pseudagrion* (B). *sp.* | | **A**$^{\mathbf{Ny}}$ | A$^{Ny}$ | | | | **Jan** |
| *Pseudagrion* (B) *acaciae* | **A**$^{\mathbf{Ad}}$ | | A$^{Ad}$ | A$^{Ad}$ | | **KD** | **Jan/Mar** |
| *Pseudagrion* (B) *coeleste* | **B**$^{\mathbf{Ad}}$ | | | | | | **Jan** |
| *Pseudagrion* (B) *hamoni* | **A**$^{\mathbf{Ad}}$**/KD** | | | | | | **Jan/Mar** |
| *Pseudagrion* (B) *lindicum* | **KD** | | | | | | **Mar** |
| *Pseudagrion* (B) *massaicum* | **A**$^{\mathbf{Ad}}$**/KD** | | | | C$^{Ad}$ | **KD** | **Jan/Mar** |
| FAMILY: Platycnemididae | | | | | | | |
| *Elattoneura glauca* | **A**$^{\mathbf{Ad}}$ | | | | | | **Jan** |
| **ORDER: Trichoptera** | | | | | | | |
| **SUBORDER: Annulipalpia** | | | | | | | |
| FAMILY: Hydropsychidae | | | | | | | |
| *Hydropsyche longifurca* (?) | | **1** | | | | | **Jan** |
| **PHYLUM: MOLLUSCA** | | | | | | | |
| **CLASS: BIVALVIA** | | | | | | | |
| FAMILY: Iridinidae | **A** | | | | | | **Jan** |
| *Chambardia wahlbergi* | **B** | | | | | | **Jan** |
| **CLASS: GASTROPODA** | | | | | | | |
| FAMILY: Ampullariidae | | | | | | | |
| *Lanistes ovum* | **B** | | | | C | **x** | **Jan** |
| FAMILY: Planorbidae | | | | | | | |
| Subfamily: Bulininae | | | | A | B | **x** | **Jan** |
| Subfamily: Planorbinae | | **A** | | C | C | **x** | **Jan** |
| *Bulinus* sp. | | | | C | | **x** | **Jan** |
| *Bulinus forskalii* | | | | | B | **x** | **Jan** |
| FAMILY: Succineidae | | | | | | | |
| *Oxyloma* sp. | | | | 1 | | | **Jan** |
| FAMILY: Thiaridae | | | | A | C | **x** | **Jan** |
| *Cleopatra* sp. | **B** | | | | | | **Jan** |
| *Melanoides* sp. | **B** | **B** | | | | | **Jan** |
| **PHYLUM: PLATYHELMINTHES** | | | | | | | |
| **CLASS: TURBELLARIA** | | | | 1 | | **x** | **Jan** |

| TAXA | AREAS | | | | | | |
|---|---|---|---|---|---|---|---|
| | NP | WFT | Shire River | | | | ALL |
| | | | NEM | SEM | WEM | All | |
| **PHYLUM: ANNELIDA** | | | | | | | |
| **CLASS: HIRUDINEA** | | | | | | | |
| FAMILY: Glossiphoniidae | | | | | | | |
| *Alboglossiphoniidae* sp. | | | | X | | **X** | **X** |
| *Theromyzon* sp. | | | | X | | **X** | **X** |
| **CLASS: OLIGOCHAETA** | | | | X | X | **X** | **X** |
| **PHYLUM: ARTHROPODA** | | | | | | | |
| **CLASS: ARACHNIDA** | | | | | | | |
| **ORDER: Acarina** | | | | X | X | **X** | **X** |
| **CLASS: MALACASTRACA** | | | | | | | |
| **ORDER: Decapoda** | | | | | | | |
| FAMILY: Athyidae | | | | | | | |
| *Cardinia nilotica* | | | X | X | X | **X** | **X** |
| FAMILY: Athyidae | | | | | | | |
| *Potamonautes obesus* | **X** | | | | | | **X** |
| **ORDER: Isopoda** | | | | | | | |
| FAMILY: Porcellionidae | | | | | X | **X** | **X** |
| **CLASS: INSECTA** | | | | | | | |
| **ORDER: Coleoptera** | | | | | | | |
| **SUBORDER: Adephaga** | | | | | | | |
| FAMILY: Dytiscidae | | | | X | X | **X** | **X** |
| SUBFAMILY: Hydroporinae | | | | X | | **X** | **X** |
| FAMILY: Gyrinidae | | | X | X | X | **X** | **X** |
| *Dineutus* sp. | | **X** | | | | | **X** |
| *Gyrinus* sp. | **X** | | | X | | **X** | **X** |
| FAMILY: Noteridae | | | | | | | |
| *Hydrocanthus/Canthydrus* sp. | | **X** | | | | | **X** |
| **SUBORDER: Polyphaga** | | | | | | | |
| FAMILY: Hydrochidae | | | X | | | **X** | **X** |
| FAMILY: Hydrophilidae | | **X** | | X | X | **X** | **X** |
| *Amphiops* sp. | | | | X | X | **X** | **X** |
| *Hydrophilus* sp. | | | | | X | **X** | **X** |
| FAMILY: Staphylinidae | | | | | | | |
| *Stenus* sp. | | | | | X | **X** | **X** |
| **ORDER: Diptera** | | | | | | | |
| **SUBORDER: Brachycera** | | | | | | | |
| FAMILY: Tabanidae | | | | | X | **X** | **X** |
| FAMILY: Stratiomyidae | | | | | X | **X** | **X** |
| **SUBORDER: Nematocera** | | | | | | | |
| FAMILY: Chironomidae | | **X** | | X | | **X** | **X** |
| FAMILY: Culicidae | | | | | X | **X** | **X** |
| *Anopheles* sp. | | | | X | | **X** | **X** |
| *Culex* sp. | | | | X | | **X** | **X** |
| *Uranotaenia* sp. | | | | | X | **X** | **X** |
| FAMILY: Psycodidae | | | | | X | **X** | **X** |
| **ORDER: Ephemeroptera** | | | | | | | |
| **SUBORDER: Schistonota** | | | | | | | |

| TAXA | AREAS | | | | | | |
|---|---|---|---|---|---|---|---|
| | NP | WFT | Shire River | | | | ALL |
| | | | NEM | SEM | WEM | All | |
| FAMILY: Baetidae | | **X** | X | X | X | **X** | **X** |
| FAMILY: Heptageniidae | | | | | | | |
| *Afronurus* sp. | | | X | | | **X** | **X** |
| FAMILY: Leptophlebiidae | | | X | X | | **X** | **X** |
| FAMILY: Oligoneuridae | | | | | | | |
| *Elassoneuria* sp. | | | X | | | **X** | **X** |
| FAMILY: Polymitarcidae | | | | | | | |
| *Ephron* sp. | | | X | | | **X** | **X** |
| **SUBORDER: Pannota** | | | | | | | |
| FAMILY: Caenidae | | **X** | X | X | | **X** | **X** |
| FAMILY: Tricorythidae | | | | | | | |
| *Tricorythus* sp. | | **X** | | | | | **X** |
| **ORDER: Hemiptera** | | | | | | | |
| **SUBORDER: Heteroptera** | | | | | | | |
| FAMILY: Belostomatidae | | | | X | X | **X** | **X** |
| *Appasus* sp. | **X** | | | X | X | **X** | **X** |
| *Lethocerus niloticus* | | | | X | | **X** | **X** |
| *Limnogeton* sp. | | | | | X | **X** | **X** |
| FAMILY: Corixidae | **X** | **X** | | X | X | **X** | **X** |
| *Micronecta* sp. | | **X** | | | | | **X** |
| FAMILY: Gerridae | | | | X | | **X** | **X** |
| FAMILY: Hebridae | | | | | | | |
| *Hebrus* sp. | **X** | | X | | | **X** | **X** |
| FAMILY: Hydrometridae | | | | | | | |
| *Hydrometra* sp. | **X** | | X | X | | **X** | **X** |
| FAMILY: Mesoveliidae | | | | | | | |
| *Mesovelia* sp. | | | X | | X | **X** | **X** |
| FAMILY: Naucoridae | | **X** | X | X | | **X** | **X** |
| *Macrocoris* sp. | | **X** | | | | | **X** |
| *Naucoris* sp. | | | | X | X | **X** | **X** |
| FAMILY: Nepidae | | | | | | | |
| *Ranatra* sp. | **X** | | X | | | **X** | **X** |
| FAMILY: Notonectidae | | | | | | | |
| *Nychia limpida* | | | | X | X | **X** | **X** |
| FAMILY: Paraphrynoveliidae | | | | | | | |
| *Paraphrynovelia* sp. | | | | | X | **X** | **X** |
| FAMILY: Pleidae | | | | | | | |
| *Plea* sp. | | | | X | X | **X** | **X** |
| FAMILY: Veliidae | | **X** | | X | X | **X** | **X** |
| *Rhagovelia* sp. | | | X | X | | **X** | **X** |
| *Tenagovelia* sp. | | | X | | | **X** | **X** |
| **ORDER: Odonata** | | | | | | | |
| **SUBORDER: Anisoptera** | | | | | | | |
| FAMILY: Aeshnidae | | | | | | | |
| *Anax* sp. | **X** | | | | | | **X** |
| *Anax imperator* | | | | | | | |
| *Anax tristis* | | | | | | | |

| TAXA | AREAS | | | | | | |
|---|---|---|---|---|---|---|---|
| | NP | WFT | Shire River | | | | ALL |
| | | | NEM | SEM | WEM | All | |
| FAMILY: Gomphidae | | | | | | | |
| *Crenigomphus* sp. | | | X | | | **X** | **X** |
| *Gomphidia* sp. | **X** | | | | | | **X** |
| *Ictinogomphus ferox* | | | | | | | |
| *Paragomphus* sp. | | **X** | | | | | **X** |
| FAMILY: Libellulidae | | **X** | | X | X | **X** | **X** |
| *Acisoma variegatum* | | | | | | | |
| *Aethriamantha rezia* | | | | X | | **X** | **X** |
| *Brachythemis leucosticta* | | | | | | | |
| *Crocothemis erythraea* | | | | | | | |
| *Diplacodes lefebvrii* | | | | | | | |
| *Diplacodes luminans* | | | | | | | |
| *Hemistigma albipunctum* | | | | | | | |
| *Nesciothemis farinosa* | | | | | | | |
| *Olpogastra lugubris* | **X** | | | | | | **X** |
| *Orthetrum* sp. | **X** | | | | | | **X** |
| *Orthetrum brachiale* | | | | | | | |
| *Orthetrum chrysostigma* | | | | | | | |
| *Orthetrum stemmale* | | | | | | | |
| *Orthetrum trinacria* | | | | | | | |
| *Pantala flavescens* | | | | | | | |
| *Rhyothemis semihyalina* | | | | | | | |
| *Tholymis tillarga* | | | | | | | |
| *Tramea basilaris* | | | | | | | |
| *Trithemis* sp. | | **X** | | X | | **X** | **X** |
| *Trithemis annulata* | | | | | | | |
| *Urothemis assignata* | | | | | | | |
| *Urothemis edwardsii* | | | | | | | |
| *Zygonyx torridus* | | | | | | | |
| **SUBORDER: Zygoptera** | | | | | | | |
| FAMILY: Coenagrionidae | | **X** | X | X | X | **X** | **X** |
| *Agriocnemis* sp. | | | | X | | **X** | **X** |
| *Agriocnemis gracile* | | | | | | | |
| *Ceriagrion glabrum* | | | | | | | |
| *Ceriagrion kordofanicum* | | | | | | | |
| *Ischnura senegalensis* | | | | | | | |
| *Pseudagrion* sp. | **X** | **X** | X | X | | **X** | **X** |
| *Pseudagrion* (A) *kersteni* | | | | | | | |
| *Pseudagrion* (B). *sp.* | | **X** | X | | | **X** | **X** |
| *Pseudagrion* (B) *acaciae* | | | | | | | |
| *Pseudagrion* (B) *coeleste* | | | | | | | |
| *Pseudagrion* (B) *hamoni* | | | | | | | |
| *Pseudagrion* (B) *lindicum* | | | | | | | |
| *Pseudagrion* (B) *massaicum* | | | | | | | |
| FAMILY: Platycnemididae | | | | | | | |
| *Elattoneura glauca* | | | | | | | |
| **ORDER: Trichoptera** | | | | | | | |

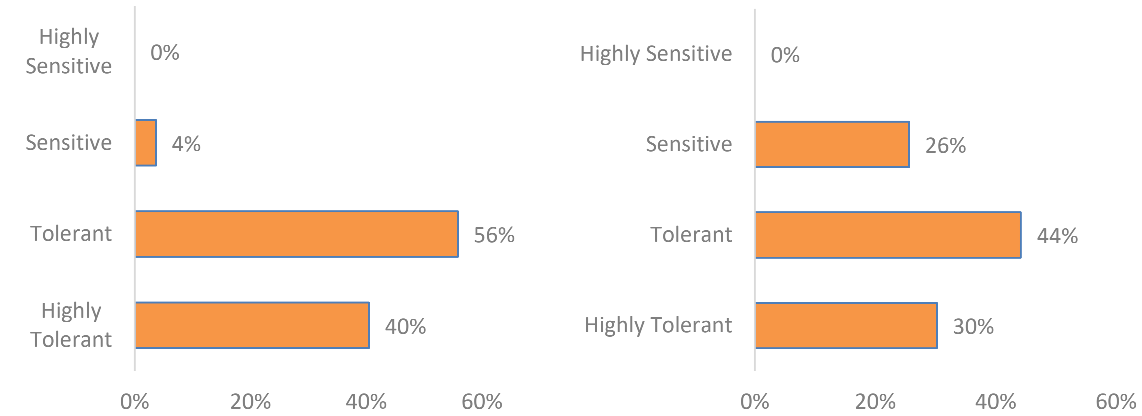
| TAXA | AREAS | | | | | | |
|---|---|---|---|---|---|---|---|
| | NP | WFT | Shire River | | | | ALL |
| | | | NEM | SEM | WEM | All | |
| **SUBORDER: Annulipalpia** | | | | | | | |
| FAMILY: Calamoceratidae | | | | | | | |
| *Anisocentropus usambarensis* | | | | | | | |
| FAMILY: Hydropsychidae | | | | | | | |
| *Aethaloptera dispar* | | | | | | | |
| *Amphipsyche senegalensis* | | | | | | | |
| *Hydropsyche longifurca* (?) | | **X** | | | | | **X** |
| *Macrostemum capense* | | | | | | | |
| *Macrostemum inscriptum* | | | | | | | |
| FAMILY: Leptoceridae | | | | | | | |
| *Athripsodes fissus* | | | | | | | |
| *Leptocerina mlanjensis* | | | | | | | |
| *Oecetis rama* | | | | | | | |
| *Parasetodes maguirus* | | | | | | | |
| *Trichosetodes anysa* | | | | | | | |
| **SUBORDER: Spicipalpia** | | | | | | | |
| FAMILY: Hydroptilidae | | | | | | | |
| **PHYLUM: MOLLUSCA** | | | | | | | |
| **CLASS: BIVALVIA** | | | | | | | |
| FAMILY: Iridinidae | | | | | | | |
| *Chambardia wahlbergi* | **X** | | | | | | **X** |
| **CLASS: GASTROPODA** | | | | | | | |
| FAMILY: Ampullariidae | | | | | | | |
| *Lanistes ovum* | **X** | | | | X | **X** | **X** |
| FAMILY: Planorbidae | | | | | | | |
| Subfamily: Bulininae | | | | X | X | **X** | **X** |
| Subfamily: Planorbinae | | | | X | X | **X** | **X** |
| *Bulinus* sp. | | | | X | X | **X** | **X** |
| *Bulinus forskalii* | | | | | X | **X** | **X** |
| FAMILY: Succineidae | | | | | | | |
| *Oxyloma* sp. | | | | X | | **X** | **X** |
| FAMILY: Thiaridae | | | | | | | |
| *Cleopatra* sp. | **X** | | | | | | **X** |
| *Melanoides* sp. | **X** | **X** | | X | X | **X** | **X** |
| **PHYLUM: PLATYHELMINTHES** | | | | | | | |
| **CLASS: TURBELLARIA** | | | | | | | |

# C: Community Composition – Aquatic macro-invertebrates

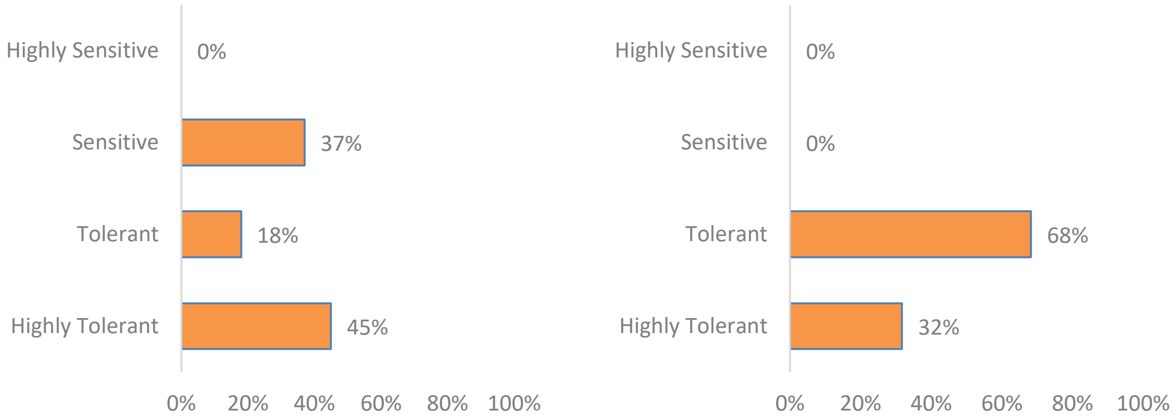
## West-flowing tributaries

### Sensitivity Ratings

Taxa distribution recorded in January 2016 at each river site (RV), based on their combined (abundance) sensitivity index (SASS5) are presented below.




**Community distribution for taxa encountered in the Mwamphanzi River (RV-01) on the left and the Nkhuzi River (RV-02) on the right.**

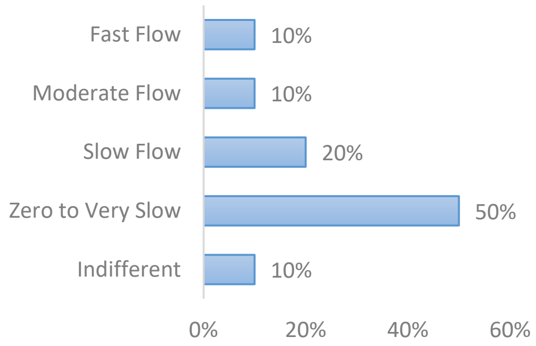


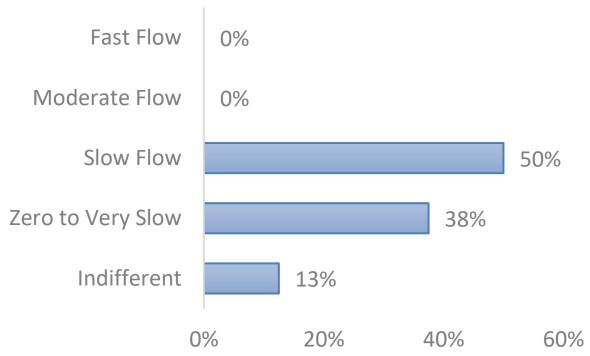

**Community distribution for taxa encountered in the Maperera River (RV-03) on the left and the Limphangwi River (RV-04) on the right.**

Tolerant to highly tolerant taxa were dominant at all four river sites sampled, with no sensitive taxa recorded at the Limphangwi River site (RV-04). Sensitive taxa were relatively well represented in the taxa-poor Nkhuzi and Maperera River sites (RV-02 and RV-03).

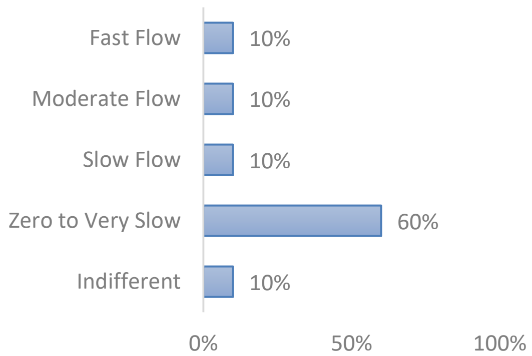
**Current Speed Preferences**

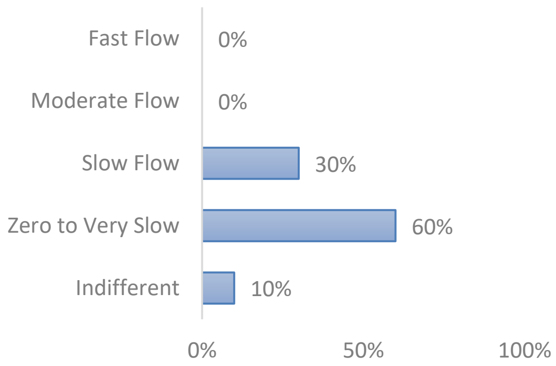
Taxa distribution recorded in January 2016 at each river site (RV), based on their preference for the different flow habitats available are presented below.




**Current speed preferences for taxa recorded in the Mwamphanzi River on the left and the Nkhuzi River at the right.**



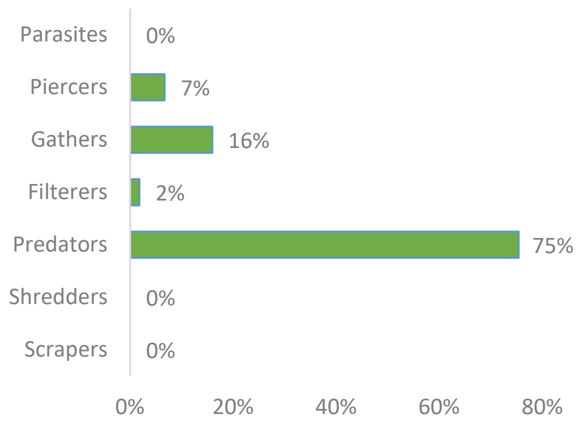



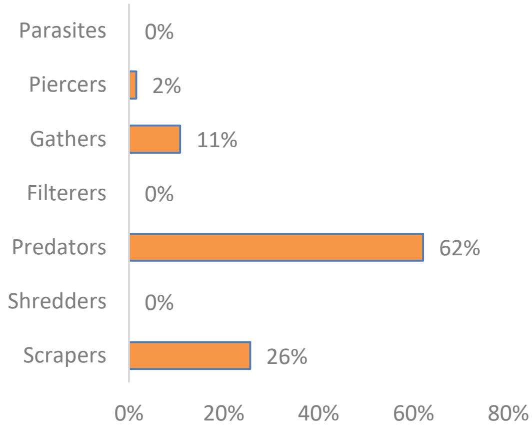

**Current speed preferences for taxa recorded in the Maperera River on the left and the Limphagweni River at the right.**

Taxa associated with very slow to zero flow habitats dominated in the Mwamphanzi, Maperera and Limphagweni River sites, followed by taxa associated with slow flows. In the Nkhunzi River, slow flow taxa dominated followed by those preferring zero to very slow flowing habitats.

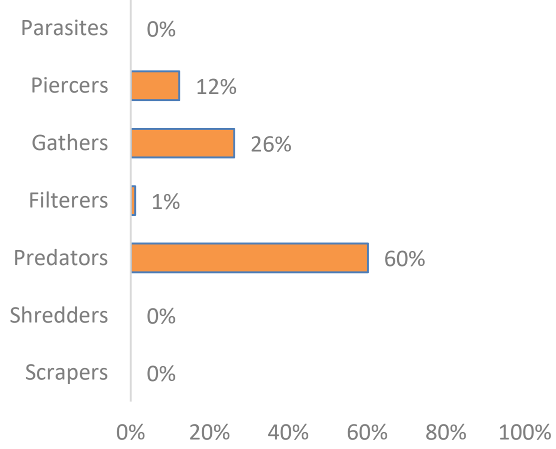
**Functional Feeding Groups**

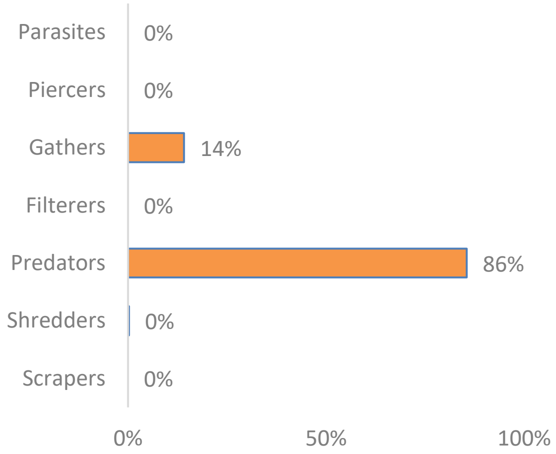
Taxa distribution recorded in January 2016 at each river site (RV), based on their combined (abundance) functional feeding group preference (FFG) are presented below.




**Community distribution for taxa encountered in the Mwamphanzi River (RV-01) on the left and the Nkhuzi River (RV-02) on the right, based on functional feeding groups.**



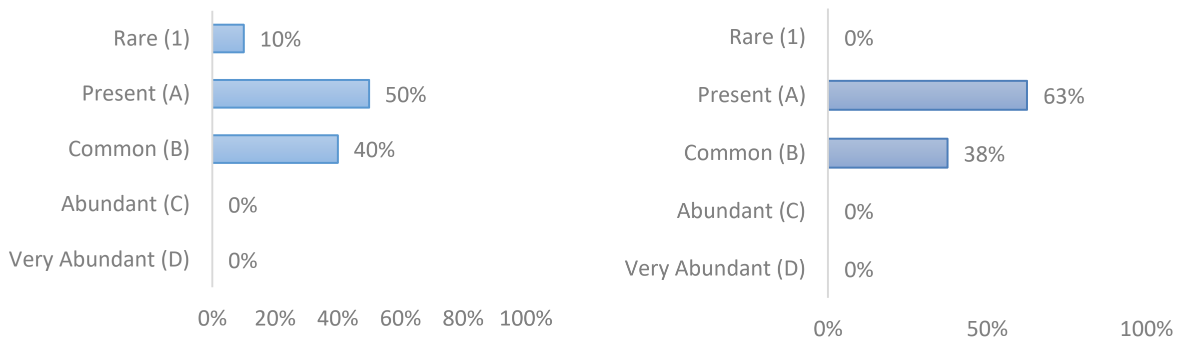




**Community distribution for taxa encountered in the Maperera River (RV-02) on the left and the Limphangwi River (RV-04) on the right, based on functional feeding groups.**

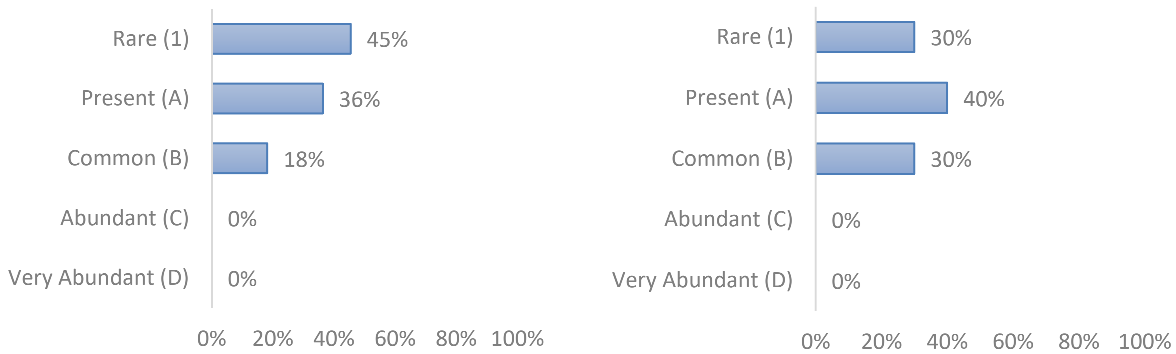
In all four the river sites, predators dominated followed by gathering collectors in the Mwamphanzi, Maperera and Limphangwi Rivers. Scrapers, which were absent at these three river sites, were the second most abundant FFG in the Nkhuzi River (RV-02).

### Abundance Ratings

The distribution of the overall community abundance are illustrated per river site below.




**Distribution the abundance ratings of taxa recorded in the Mwamphanzi River on the left, and the Nkhunzi River on the right.**



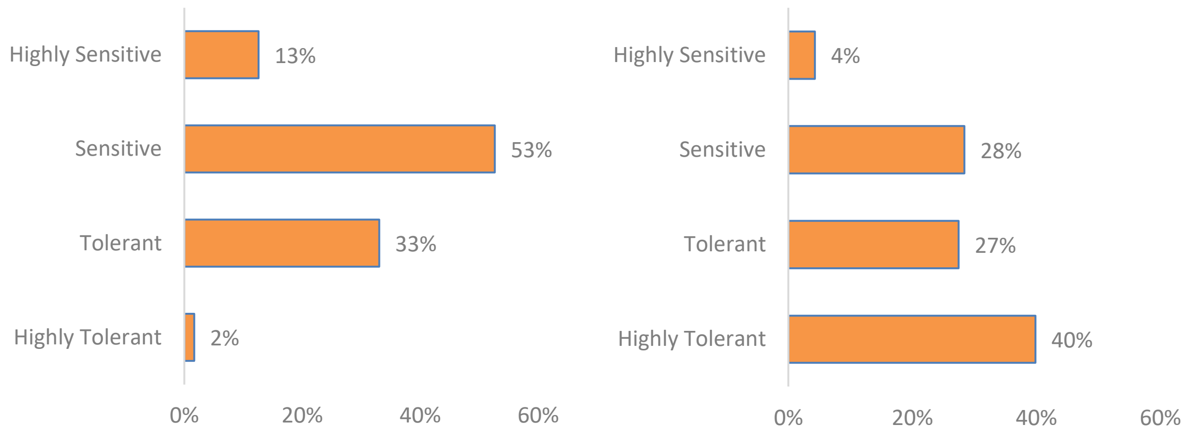

**Distribution the abundance ratings of taxa recorded in the Maperera River on the left, and the Limphangwi River on the right.**

Most taxa were recorded in abundances of 2 – 10 (A), followed by those recorded in numbers of 11 – 100 (B). At the Maperera River site, a high number of taxa were represented by only one specimen.

## Shire River – NEM and SEM sites

### Sensitivity Ratings

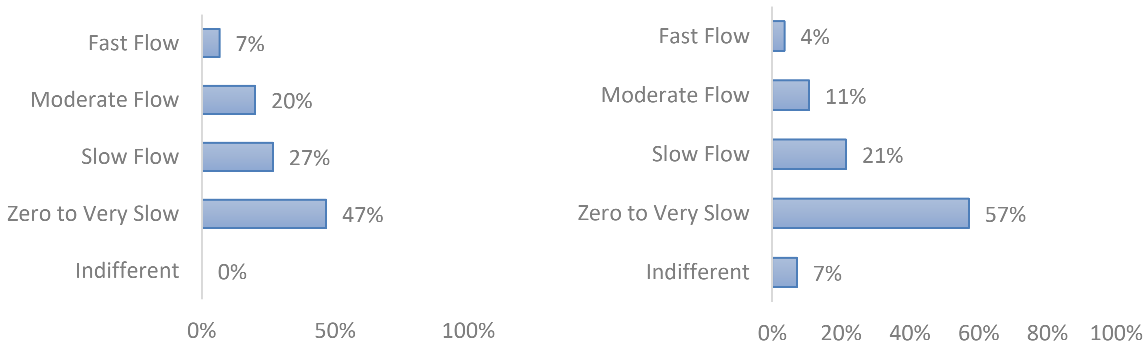
The combined taxa distribution recorded in January 2016 at sites in the north-western (NEM) and south-western (SEM) portions of the Elephant Marshes in the Shire River, focusing on taxa sensitive to pollution.




**Community distribution for taxa focusing on sensitivity, encountered in the Shire River at sites in the north-western (NEM) portion of the Elephant Marshes on the left, and the south-western (SEM) portion on the right.**

### Current Speed Preferences

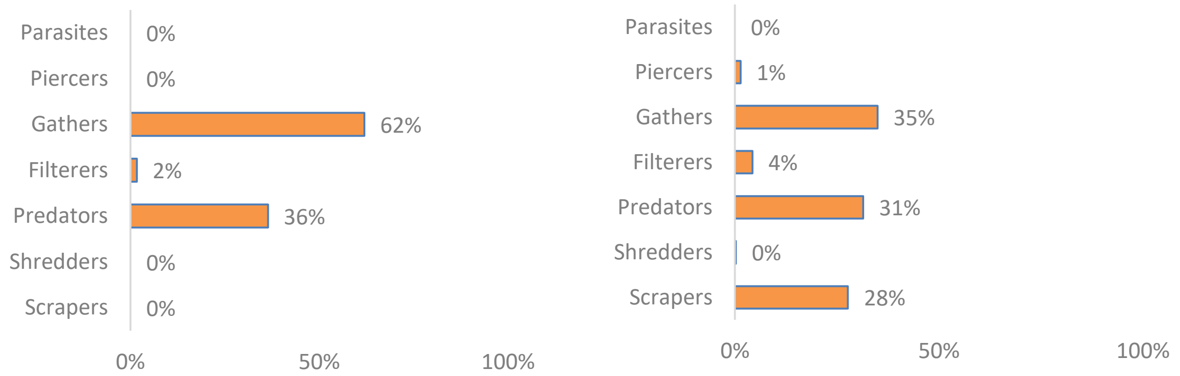
The combined taxa distribution recorded in January 2016 at sites in the north-western (NEM) and south-western (SEM) portions of the Elephant Marshes in the Shire River, focusing on taxa preferences for different flow velocities.




**Community distribution for taxa focusing on flow preference, encountered in the Shire River at sites in the north-western (NEM) portion of the Elephant Marshes on the left, and the south-western (SEM) portion on the right.**

**Functional Feeding Groups**

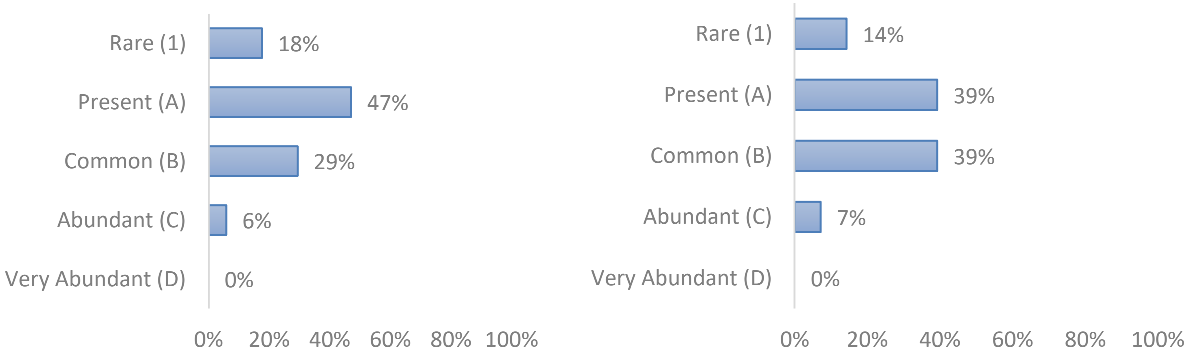
The combined taxa distribution recorded in January 2016 at sites in the north-western (NEM) and south-western (SEM) portions of the Elephant Marshes in the Shire River, focusing on functional feeding groups.




**Community distribution for taxa focusing on functional feeding groups, encountered in the Shire River at sites in the north-western (NEM) portion of the Elephant Marshes on the left, and the south-western (SEM) portion on the right.**

**Abundance Ratings**

The combined taxa distribution recorded in January 2016 at sites in the north-western (NEM) and south-western (SEM) portions of the Elephant Marshes in the Shire River, focusing on abundances.

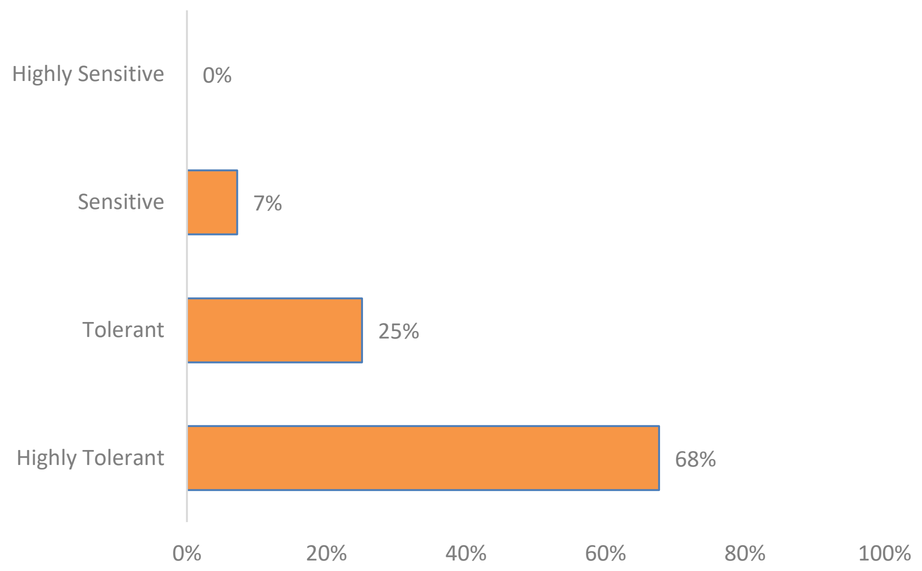



**Community distribution for taxa focusing on abundance ratings, encountered in the Shire River at sites in the north-western (NEM) portion of the Elephant Marshes on the left, and the south-western (SEM) portion on the right.**

# Western Clear Water Lake

### Sensitivity Ratings

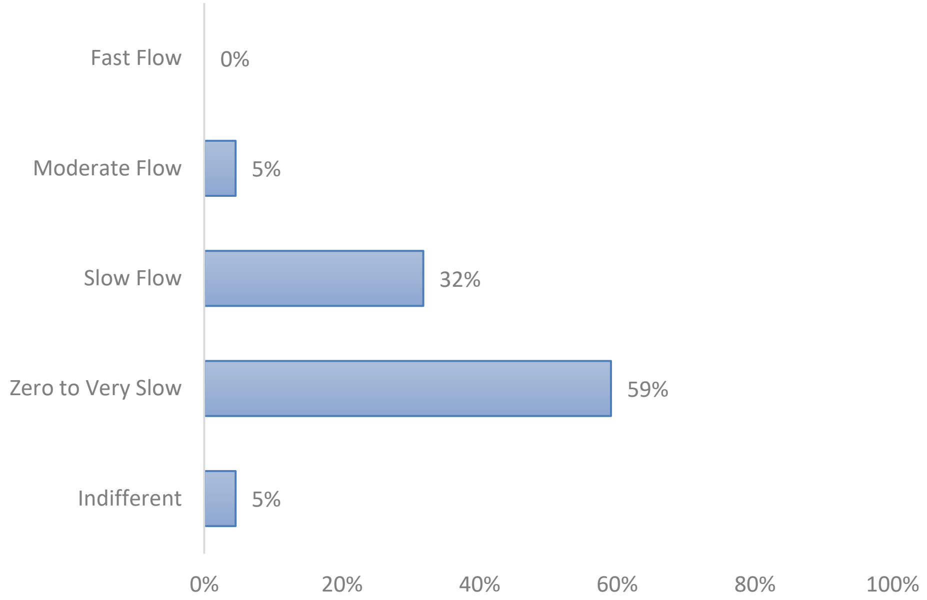
The combined taxa distribution recorded in January 2016 at sites in the western clear water lake (WEM) portion of the Elephant Marshes adjacent (but linked) the Shire River, focusing on taxa sensitive to pollution.




**Community distribution for taxa focusing on sensitivity, encountered in the western clear-water lake.**

### Current Speed Preferences

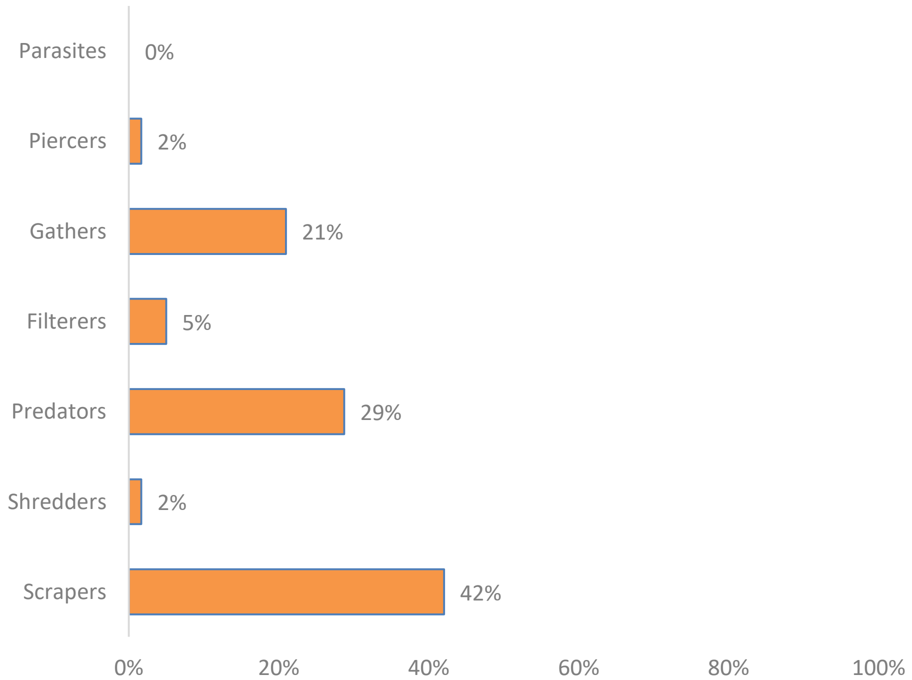
The combined taxa distribution recorded in January 2016 at sites in the western clear water lake (WEM) portion of the Elephant Marshes adjacent (but linked) the Shire River, focusing on taxa preferences for different flow velocities.




**Community distribution for taxa focusing on flow preference, encountered in the western clear-water lake.**

**Functional Feeding Groups**

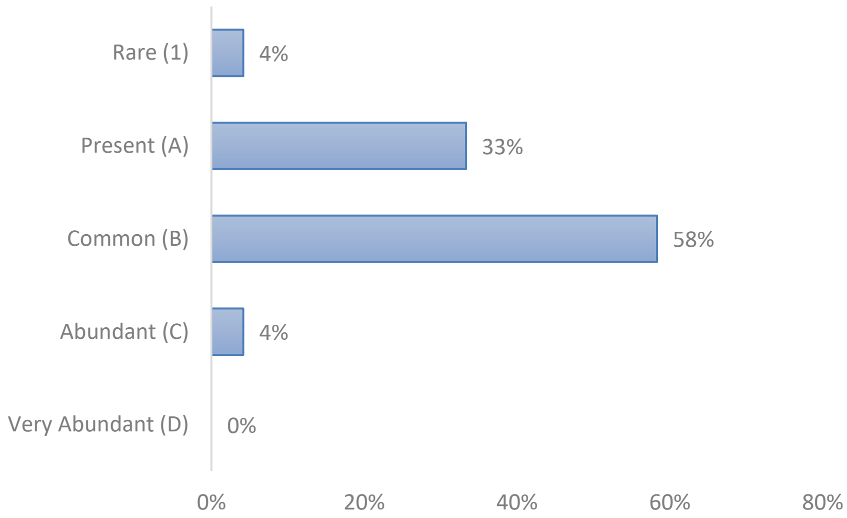
The combined taxa distribution recorded in January 2016 at sites in the western clear water lake (WEM) portion of the Elephant Marshes adjacent (but linked) the Shire River, focusing on functional feeding groups.




**Community distribution for taxa focusing on functional feeding groups, encountered in the western clear-water lake.**

**Abundance Ratings**

The combined taxa distribution recorded in January 2016 at sites in the western clear water lake (WEM) portion of the Elephant Marshes adjacent (but linked) the Shire River, focusing on abundances.




**Community distribution for taxa focusing on abundance ratings, encountered in the western clear-water lake.**

# Appendix 3: Butterflies

## A: Photos of sites 1, 2 and 4

### Site 1. South West Side

**The edge of the marsh**

**In the marsh approaching a bank with typical mix of plants (Note no trees)**

**Man coming out of the marsh**

**Papyrus plus Polygononum**

**Local fishermen, where do they get the trees from to make canoes as there are none? Most canoes are very old**

**Meagre catch: two people, half a day of fishing**

**Collecting in Polygononum in Marsh. Home of *Neptis jordani.* Two other species possibly anticipated. Acraea rahira, Mylothris rubicostata were absent**

**Marsh with submerged plants**

## Site 2. East Side North

**Phoenix Palms left for tapping**

**Phoenix Palms near marsh edge**

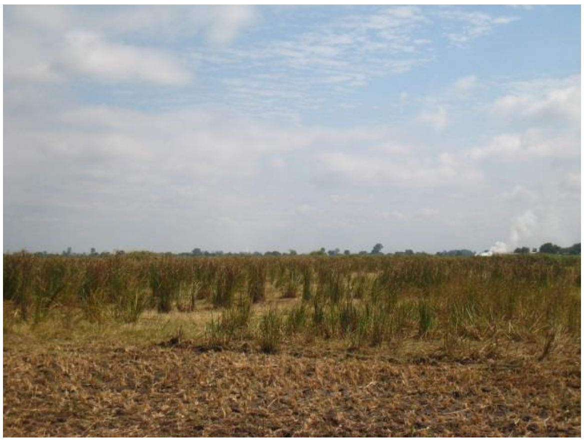
**Crops to marsh edge**

**Old termite mounds for plant diversity**

**Edge of marsh**

**Fire burning in Marsh. Clearing for cultivation**

**Marsh edge denuded of vegetation**



**Old rice paddies**

**Subsistence crop drying**

## Site 4. East Side South


Side of marsh from road


Ruo River near entrance to marsh


Crossing Ruo river when previous circulation of marsh


Redirected Ruo river post 2014/2015 floods. Note all vegetation washed away

## B: List of species per site and Butterflies recorded (Dowsetts 2002) of the three Conservation areas Lengwe, Majete, Mwabvi.

| Butterfly Sampling Sites | Latitude (S) | Longitude (E) |
|---|---|---|
| | 16°18'18.9" | 34°58'11.0" |
| | 16°14'55.5" | 35°00'30.9" |
| | 16°17'34.1" | 35°01'38.5" |
| | 16°27'28.7" | 35°10'17.7" |
| | 16°28'36.0" | 35°11'18.2" |
| | 16°31'50.8" | 35°04'28.3" |
| | 16°31'00.2" | 35°04'46.9" |
| | 16°16'31.8" | 34°55'06.8" |
| | 16°10'02.2" | 34°52'08.1" |
| | 16°12'51.3" | 34°47'03.7" |

West Side South: Kaombe Site GPS 24/25.6.15 63m S16˚31916´ E035˚04410´

East Side North: 1/2/3 26.6.15 64m (a) S16˚11315´ E034˚58196´ (b) S16˚14786´ E035˚00519 (c) S16˚13013´ E035˚01619´

West Side North: Nyala Nchalo 27.6.15 80m S16˚1054264´ E034˚5127241´

East Side South: 4/5/6 29/6/15 -S16˚02126´ E034˚51419´ 93m -S16˚28590´ E035˚11324´

| Elephant Marshes Sites 1-4 | | | | | |
|---|---|---|---|---|---|
| Site (1 day each) | 1<br>West Side South Kaombe Site | 2<br>East Side North | 3<br>West Side North | 4<br>East Side South | 5<br>Butterflies of Lower Shire Reserves Dowsett List |
| **Hesperiidae (Skippers)** | | | | | |
| *Coeliades forestan* | | ● | | | ● |
| *Coeliades pisistratus* | | | | | ● |
| *Tagiades flesus* | | | | | ● |
| *Calleagris jamesoni* | | | | | ● |
| *Sarangesa motozi* | | | | | ● |
| *Netrobalane canopus* | | | | | ● |
| *Spialia dromus* | | | | | ● |
| *Acada biseriata* | | | | | ● |
| *Borbo fatuellus* | ● | | ● | | ● |
| Sarangesa phidyle | ● | | | | |
| Gegenes hottentota | | ● | | | |
| Borbo gemella | | | ● | | |
| Borbo borbonica | ● | | | | |
| | | | | | |
| **Papilionidae (Swallowtails)** | | | | | |
| *Papilio dardanus* | ● | | | | ● |
| *Papilio constantinus* | | | | | ● |
| *Papilio nireus* | ● | | | | ● |
| *Papilio demodocus* | ● | ● | ● | | ● |
| *Graphium angolanus* | | | | | ● |

| Elephant Marshes Sites 1-4 | | | | | |
|---|---|---|---|---|---|
| **Site (1 day each)** | **1 West Side South Kaombe Site** | **2 East Side North** | **3 West Side North** | **4 East Side South** | **5 Butterflies of Lower Shire Reserves Dowsett List** |
| *Graphium leonidas* | | | | | ● |
| *Graphium antheus* | | | | | ● |
| *Graphium porthaon* | | | | | ● |
| | | | | | |
| **Pieridae (Whites)** | | | | | |
| *Catopsilia florella* | ● | ● | ● | ● | ● |
| *Eurema hecabe* | ● | ● | ● | | ● |
| *Eurema brigitta* | | ● | ● | | ● |
| *Eurema hapale* | | | | | ● |
| *Pinacopteryx eriphia* | ● | ● | | | ● |
| *Nepheronia argia* | | | | | ● |
| *Nepheronia thalassina* | | | | | ● |
| *Nepheronia buqueti* | | ● | ● | | ● |
| *Eronia leda* | ● | | | | ● |
| *Colotis amata* | ● | ● | ● | ● | ● |
| *Colotis vesta* | ● | ● | | | ● |
| *Colotis ione* | ● | ● | | | ● |
| *Colotis regina* | | | | | ● |
| *Colotis danae* | | | | | ● |
| *Colotis antevippe* | | | | | ● |
| *Colotis evenina* | ● | ● | | | ● |
| *Colotis evippe* | | | | | ● |
| *Colotis evagore* | ● | | | | ● |
| *Belenois zochalia.* | | | | | ● |
| *Belenois aurota* | ● | ● | ● | | ● |
| *Belenois creona* | ● | ● | ● | | ● |
| *Belenois thysa* | ● | | | | ● |
| *Belenois gidica* | ● | | | | ● |
| *Appias epaphia* | | | | | ● |
| *Leptosia alcesta* | ● | | ● | | ● |
| Dixea doxo | | | | | |
| Mylothris agathina | ● | ● | ● | ● | |
| Colotis eris | | ● | | | |
| | | | | | |
| **Lycaenidae (blues)** | | | | | |
| *Alaena nyassa* | | | | | ● |
| *Pentila tropicalis* | | | | | ● |
| *Baliochila hildegarda* | | | | | ● |
| *Cnodontes vansomereni* | | | | | ● |
| *Lachnocnema laches* | ● | | | ● | |
| *Axiocerces tjoana* | | | ● | | ● |
| *Hypolycaena philippus* | | | | | ● |
| *Virachola* sp. | | | | | ● |
| *Anthene amarah* | | | ● | | ● |

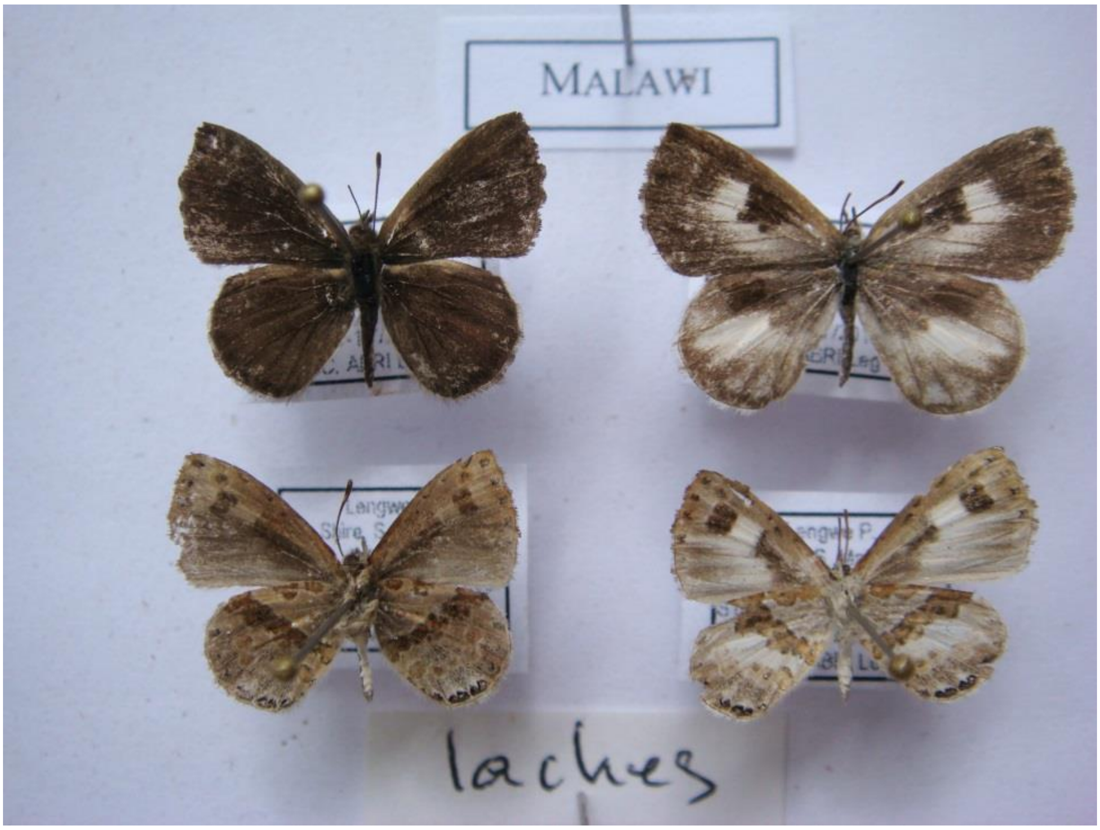
| Elephant Marshes Sites 1-4 | | | | | |
|---|---|---|---|---|---|
| **Site (1 day each)** | **1 West Side South Kaombe Site** | **2 East Side North** | **3 West Side North** | **4 East Side South** | **5 Butterflies of Lower Shire Reserves Dowsett List** |
| *Petrelea sichela* | | | | | ● |
| *Cacyreus lingeus* | ● | | | ● | ● |
| *Leptotes telicanus* | ● | ● | ● | ● | ● |
| *Tuxentius calice* | ● | ● | ● | ● | ● |
| *Zizeeria knysna* | ● | ● | ● | ● | ● |
| *Zizula hylax* | | ● | ● | ● | ● |
| *Azanus jeseous* | ● | | ● | | |
| *Euchrysops malathana* | | | | | ● |
| *Euchrysops barkeri* | | | | | ● |
| Tauracus syarbis | | | ● | | |
| Lachnocnema bibulus | | | | | ● |
| Axiocerces amanga | ● | | | | |
| (Spindasis) natalensis | ● | | | | |
| Freyeria trochylus | ● | | | | |
| Eicochrysops messapus | ● | | | | |
| Tuxentius melaena | | | ● | | |
| Lampides boeticus | | ● | ● | ● | |
| Tuxentius melaena | | | ● | | |
| Eicochrysops hippocrates | | | ● | | |
| Anthene talboti | | ● | | | |
| | | | | | |
| **Libytheidae (snout)** | | | | | |
| *Libythea labdaca* | | | | | ● |
| | | | | | |
| **Nymphalidae (nymphalids)** | | | | | |
| *Charaxes jahlusa* | ● | | | | ● |
| *Charaxes achaemenes* | ● | | | | ● |
| *Charaxes saturnus* | ● | ● | ● | ● | ● |
| *Charaxes castor* | ● | | ● | | ● |
| *Charaxes brutus* | ● | ● | | ● | ● |
| *Charaxes guderiana* | | | | | ● |
| *Charaxes phaeus* | ● | | | | ● |
| *Charaxes ethalion* | ● | | | | ● |
| *Charaxes bohemani* | | | | | ● |
| *Charaxes varanes* | ● | ● | ● | | ● |
| *Charaxes candiope* | ● | ● | | | ● |
| *Charaxes zoolina* | ● | | ● | | ● |
| *Euxanthe wakefieldi* | | | | | ● |
| *Euphaedra neophron* | | | | | ● |
| *(Euphaedra orientalis)* | | | | | |
| *Hamanumida daedalus.* | ● | ● | ● | | ● |
| *Pseudacraea lucretia* | | | | | ● |
| *Neptis saclava* | ● | | ● | ● | ● |
| *Neptis kiriakoffi* | ● | | ● | | ● |

| Elephant Marshes Sites 1-4 | | | | | |
|---|---|---|---|---|---|
| **Site (1 day each)** | **1 West Side South Kaombe Site** | **2 East Side North** | **3 West Side North** | **4 East Side South** | **5 Butterflies of Lower Shire Reserves Dowsett List** |
| *Byblia anvatara/ilithya* | ● | | | | ● |
| *Neptidopsis ophione* | | | | | ● |
| *Eurytela dryope* | ● | | ● | | ● |
| *Hypolimnas misippus* | | | | | ● |
| *Hypolimnas anthedon* | | | | ● | ● |
| *Salamis anacardii* | | | | | ● |
| *Salamis parhassus* | | | | | ● |
| *Junonia oenone* | ● | | ● | | ● |
| *Junonia hierta* | ● | | | | ● |
| *Junonia orithya* | | | | | ● |
| *Junonia natalica* | ● | | | | ● |
| *Catacroptera cloanthe* | | | | | ● |
| *Vanessa cardui* | | | | | ● |
| (*Antanartia* spp.) | | | | | |
| *Phalanta phalantha* | | | | | ● |
| J. cuama | ● | | | | |
| Ch. violetta | ● | | | | |
| Cyrestus camillus | | | | | |
| | | | | | |
| **Acraeidae (acraeas)** | | | | | |
| *Acraea serena* | ● | ● | ● | ● | ● |
| *Acraea encedon* | ● | ● | ● | ● | ● |
| *Acraea natalica* | | | | | ● |
| *Acraea atergatis* | | | | | ● |
| *Acraea oncaea* | | | | | ● |
| | | | | | |
| **Satyridae (browns)** | | | | | |
| *Melanitis leda* | ● | | ● | | ● |
| *Bicyclus anynana* | ● | | ● | | ● |
| *Bicyclus safitza* | ● | | ● | | ● |
| *Henotesia perspicua* | | | | | ● |
| *Ypthima asterope* | | | | | ● |
| Bicyclus ena | | | | | |
| | | | | | |
| **Danaidae** | | | | | |
| *Danaus chrysippus* | ● | ● | ● | ● | ● |
| Amauris niavus | | ● | | | |
| | **53** | **33** | **36** | **20** | **101** |
| | **Total species 62** | | | | |
| 61 Species | | | | | |
| 22 not recorded from the Shire Geography | | | | | |
| 1 species new to Malawi | | | | | |
| 1 subspecies new to science. Closest affinity W. Madagascar opposite the site in S. Malawi latitudinally | | | | | |

## C: Comparison of Colotis amata races in Africa sharing new race (?Shirensis m.s.)

### *Lachnocnema laches*

*Lachnocnema laches* is a new species record to Malawi. This may have been recorded previously as *L. durbani* (impossible to tell without reference to material) and the genus is reclusive, and is usually food feeding on exudate of plant hoppers and scale insects. Of the 61 species recorded in four days field sampling, one species is new to science, and one is new to Malawi. Another has not been recorded by the Malawian Butterfly Authority for more than 20 years and 15 species were not recorded in the checklists made by the Parks (101 species) in 2002 or earlier. Clearly there is much more butterfly work to be done in Malawi to have a complete reference list.

- 


**The newly recorded *Lachnocnema laches*. Males are shown on the left and females on the right.**

# D: Malawian butterfly species list and their sites

Summary of species included in the table below:

- Named species - 607
- Named sub species - 23
- New species or unplaced species - 46
- Species only recorded from Malawi - 60

**Butterfly species list for Malawi (updated August 2015) showing the site and person who recorded the species. B = Bernaud C = Carcasson D = Dowsett Du = Dudley F = FRIM G = Gifford H = Henning L = BMNH M = Murphy**

| Species | Site | Person |
|---|---|---|
| **Hesperiidae** | | |
| **Coeliadinae** | | |
| Coeliades anchises anchises (Gerstaecker, 1871) | Monkey Bay Mul Thyolo 12-3 | G |
| Coeliades forestan forestan (Stoll, [1782]) | Km9T 2 LNP LiwNP Lunyangwa 5 MGR MNP | G M D Du |
| | Mlunguzi 5 Zaro 2 | |
| Coeliades libeon (Druce, 1875) | Bt Mul 10-4 | G |
| Coeliades pisistratus (Fabricius, 1793) | Bt Kas 1 Liv'tonia MGR Mondwe 4 Mug 6 Mul Uz 2 | G M D |
| Coeliades sejuncta (Mabille & Vuillot, 1891) | Mul Thyolo 4 | G |
| | | |
| **Hesperiinae** | | |
| Acada biseriata (Mabille, 1893) | Chis 2 CF 7 KR 3 LiwNP MNP Mpindika 7 Mug 2 Nk 4 | G M D Du |
| | Ntchisi 3 Shire Highlands Plat 12-8 Z (Collins) | |
| Acleros mackenii (Trimen, 1868) | Chikangawa 3 Lunyangwa 5 Mug 2&6 Nk 5, 9&12 | G M |
| | Ntchisi 5 & 11-12 Ruo 9-10 Z (Collins) | |
| Acleros placidus (Plotz, 1879) | Misident Nkhata Bay Closed forests 5-8 | G |
| Acleros ploetzi Mabille 1890 | Mul 8 Nkata Bay closed forests | G |
| Ampittia capenas (Hewitson, 1868) | E Nyika KR 3 Kazuni 3 LiwNP L'stonia WS 2 Nk 2 | G M |
| | Ruo 4 & 9-10 Shire Highlands 2-5 | |
| Ampitta parva Aurivillius, 1925 | Ft Man 4 Uzuzu Clough | M |
| Andronymus caesar philander (Hopffer, 1885) | Bt Chis 2&5 Chinteche Kalwe 3 Liv'stonia Mangochi | G M |
| | Mbowe Dam 4 Nk 4-6 & 9 Ruo 9-10 Zomba 2-8 | |
| Andronymus evander (Mabille, 1890) | Misident | |
| | Mkw 5 | G |
| Andronymus fenestrella Bethune-Baker, 1908 | Chinteche 8 Kalwe 4 | G M |
| Andronymus helles Evans 1937 | Misident | |
| | Mkw 5 | G |
| Andronymus neander neander (Plotz, 1884) | Kalwe 5 Kas 1 Km18T 10 Lik 12 LiwNP Mug 5 Nk 12 | G M Du |
| | Ntchisi 3 | |
| Artitropa erinnys nyasae Riley, 1925 | Crater 4 Limbe Nk 3-4 & 7-9 Ntchisi 3 Ruo 2&9-10 Thyolo 5 | G M |
| | Z (Collins) | |

| Species | Site | Person |
|---|---|---|
| Artitropa milleri milleri Riley, 1925 | Mug 2&7 | M |
| Astictopterus punctulata (Butler, 1895) | Dedza 2 Dz 2 Ntchisi 2 | G M |
| Astictopterus stellata mineni (Trimen, 1894) | Kalwe 5 Mkw Maiwale Mul Thyolo Uyuzi 3 Uzuzu 3 | G M |
| | Zomba 1-4 | |
| Artitropa reducta Aurivillius, 1925 | Kalwe 4-5 Mul 12&2 | G M |
| Borbo borbonica borbonica (Boisduval, 1833) | All areas 1-5 Mt man 4 Uyuzi 4 | G M |
| Borbo detecta (Trimen, 1893) | Kaseramba 12 Mangochi Mkw 9 Mug 5 Mul Ngerenge | G M |
| | Vizara 1-3 6-10 | |
| Borbo fallax (Gaede, 1916) | Domira Bay Ekwendeni Kalwe 5 Limbe 5 Mangochi Mvera 3 | G M |
| | Mug 6 | |
| Borbo fatuellus fatuellus (Hopffer, 1855) | Kalwe 5 Kazuni 3 LiwNP LNP MGR MNP Mug 6 Nk 4 | G M D Du |
| | Ntchisi 3 Ruo 4&9-10 Uyuzi 3 | |
| Borbo gemella (Mabille, 1884) | Bt MGR 5 Mul Nk 3 Nyamkhowa Zomba 4-6 | G M |
| Borbo holtzii (Plotz, 1883) | All areas Nk 6 Ntchisi 5 Zomba 5-7 | G M |
| Borbo lugens (Hopffer, 1855) | All areas throughout Kalwe 6 Lik 5 LiwNP | G M Du |
| Borbo micans (Holland, 1896) | Kahango River 9 Lunyangwa swamp 5-6 Monkey Bay Mul | G M |
| | E.Nyika Zomba (Swampy areas) | |
| Borbo perobscura (Druce , 1912) | LVP 4 Mbowe Dam 4 Nyamkhowa 1-4 | G M |
| Caenides leonora dux (Evans, 1937) | Mul 1-2 | G |
| Chondrolepis niveicornis niveicornis (Plotz, 1883) | Chikangawa 4 Dz 4 Km9T 12 Mbowe Dam 4 Mt Man 4 Ntchisi 3G M | |
| | Uz 4 Plateau Areas 10-4 | |
| Chondrolepis telisignata (Butler, 1896) | Juniper 10-11 Nyika 12&4 | G M |
| Fresna ennuari (Riley, 1921) | Chilanga Lik 4&12 Lilongwe Malidade 8 Ngapani 5 Ntchisi 4 | M N |
| Fresna nyassae (Hewitson, 1878) | Bt Bandawe Mt Choma 8 Kalwe 5 L'stonia Mulanje Nk 4 | G M N |
| | Thazima 9 Thyolo | |
| Gegenes hottentota (Latreille, [1924]) | Bt Chigumula Mul 2-6 | G |
| Gegenes niso brevicornis (Plotz, 1884) | Chikangawa 3-4 Chowo 5 Juniper 3,7-8&10 LiwNP | G Du M |
| | Lunyangwa 6 Mug 6 Mul Plat Nganda 3&7 Thukutu River 8 | |
| | Uz 4 Z Plat 9-6 | |
| Gegenes pumilio (Hoffmansegg, 1804) | LiwNP N.W.Lakeshore 7&10 | G Du |
| Gorgyra bibulus Riley, 1929 | LiwNP Manchewe Mug 6 Nyamkhowa 3-4&7-10 | G M Du |
| Gorgyra johnstoni (Butler, 1894) | Deep Bay Florence Bay E Nyika 1-4 | G |
| Kedestes barbarae barbarae (Trimen, 1873) | Chowo 12 | M |
| Kedestes brunneostriga (Plotz,, 1884) | Chikangawa E Nyika 1-5&7-10 | G |
| Kedestes callicles (Hewitson, 1868) | Bt Chikwawa Kazuni 3 Likoma Namitembo Mpat 2 Mul 2-5 | G M |
| | Z (Collins) | |
| Kadestes lema linka Evans 1956 | Dedza Dz 2 Ifisa 12&4 KR 4 Ntcheu | G M |
| Kedestes marshalli Aurivillius, 1925 | KR 3 | M |
| Kedestes mohozutza (Wallengren, 1857) | Chikangawa Mul 5 | G |
| Kedestes wallengreni fenestratus (Butler, 1894) | Lik 12 Mul Plat Zomba Plat 12-8 | G M |

| Species | Site | Person |
|---|---|---|
| Kadestes wallengreni wallengreni (Trimen, 1883) | Mt Choma 8 Juniper 3,7&10 E Nyika 2-5&7-8 | G M |
| Meticella decipiens (Butler, 1896) | Ft Man 4 Kigonsera Kondowe Lunyangwa 5 Manchewe 1-4 | G M |
| | Mbowe dam 4 Mug 5-6 Nk 4-7 | |
| Meticella formosus formosus (Butler, 1894) | Chilwa Plain KR 3-4 Limbe Nk 5 E Nyika Zomba 1-4 | G M |
| Meticella formosa ssp | Ft Man 4 | M |
| Meticella medea nyika Evans, 1937 | Juniper 3 | G M |
| Metisella midas midas (Butler, 1894) | Ft Man 4 Lunyangwa 5-6 Mug 6 Nk 4-5 Zomba 2-5&7-9 | G M |
| Meticella orientalis orientalis (Aurivillius, 1925) | Chikangawa 3 J 7 Kasyauli 5 Km3 CTO 3 Lik 12 Nganda 3 | G M |
| | Ruo 10-11 Thyolo 3-5 7 9-10 12 | |
| Meticella perexellens perexellens (Butler, 1896) | Juniper 3 Nganda 3-4 | G M * |
| Meticella quadrisignatus quadrisignatus (Butler, 1894) | Limbe Ntchisi 3 Soche Mtn E Nyika Zomba 1 | G M |
| Meticella willemi (Wallengren, 1857) | Ft Man 4 Lilongwe Maiwale N.Nyassaland 1 Uzuzu 4 | G M |
| Meza larea Neave ,1910 | Mt Choma 8 Dedza Mpindika 7-8 Mul 1-7&9 | G M |
| Monza cretacea crona Evans, 1937 | Mul 2 | N |
| Monza punctata punctata (Aurivillius, 1910) | Lik 12 Mul 2 | G M |
| Parnara naso monasi (Trimen, 1889) | Kalwe 5 LiwNP Monkey Bay Mug 5 Nsanje 3 6&7 | G M Du |
| Parosmodes morantii morantii (Trimen, 1873) | Chipala FR 4 Monkey Bay Mul Nyamkhowa 2-7 Sonjo Hill 2 | G M |
| Pelopidas mathias (Fabricius, 1798) | Kasyauli 5 LiwNP Nk 5 | G M Du |
| Pelopidas thrax inconspicua (Bertoloni, 1850) | Kalwe 5 LiwNP Mt Man 4 | G M Du |
| Platylesches affinissima Strand, 1921 | LiwNP Mul 2-5&10 | G Du |
| Platylesches galesa (Hewitson, 1877) | Bt LVP 4 Limbe L'stonia 2 Luchenza Mug 6 Mul 8 Nk 2,4,6 | G M |
| Platylesches lamba Neave, 1910 | Nkhota kota E Nyika 3&8-10 | G |
| Platylesches langa Evans, 1937 | Km18T 10 Km24T 10 Mul 5&9-10 | G M |
| Platylesches moritili (Wallengren, 1857) | All areras throughout Juniper 10 Nk 4&9 | G M |
| Platylesches picanini (Holland, 1894) | Bt L'stonia 2 Mul Nkhata Bay forests Nk 4 Zomba 2-5&8 | G M |
| Platylesches rasta rasta Evans, 1937 | Kalwe Ntchisi 3 Nyamkhowa 4-6 Ruo 9-10 Uz 4 | G M |
| Platylesches robustus Neave, 1910 | Mul Nyamkhowa 7-10 | G |
| Platylesches tina Evans, 1937 | Juniper 3 Mul 10 | G M |
| Semalea arela (Mabille, 1891) | Fort Lister 6 Kalwe 4 KR 3 LVP 3 Mul 9-4 & 8 Nk 5 E Nyika | G M |
| Semalea pulvina (Plotz, 1889) | Chis 2 Mug 2&5 Ruo 2, 4&9-10 E Nyika Thyolo | G M |
| Teniorhinus harona (Westwood, 1881) | Chis 2 Kazuni 7 Lik 12 LiwNP Mpindika 7-8 | G M Du |
| | Z (Collins) | |
| Teniorhinus herilus (Hopffer, 1855) | LiwNP Mangochi Malawe Hills Mpat 3-5 | G Du |
| Zenonia anax Evans, 1937 | Kanjedza Limbe Ntchisi 5 Thyolo Zomba 3-5&9 | G M |
| Zenonia zeno (Trimen, 1864) | CF 7-8 Chowo 5 Juniper 10 Km3CTO 3 Lik-Lichenya Plat. 7 | G M |
| | Limbe 5 Lunyangwa 5 Mug 2&6 Ntchisi 3 Zomba 3-6 | |
| Zophopetes cerymica (Hewitson, 1867) | Mul 10 | Collins |
| Zophopetes dysmephila (Trimen, 1868) | Lik 3 Liv'stonia LiwNP Mul Nk 9-12 Zomba 4&6-10 | G M Du |
| | | |
| **Pyrginae** | | |

| Species | Site | Person |
|---|---|---|
| Abantis arctomarginata Lathy, 1901 | Mul Zomba 4-6 | G |
| Abantis bamptoni Collins & Larsen, 1994 | Lusangazi Nk 4&11-12 | M |
| Abantis paradisea paradisea (Butler, 1870) | Chinteche Malawe Hills Mul Ntcheu Ntchisi 5 | G M |
| | E Nyika 9-10&1-5 | |
| Abantis tettensis Hopffer, 1855 | Bt 9-12 | G |
| Abantis venosa venosa Trimen, 1899 | Chinteche Kalwe 4 Mul Mzimba 10&1-4 | G M |
| Abantis zambesiaca (Westwood, 1874) | Km3T 10 Lik 3 Mafinga Mtns 4 Mt Malawi 10 | G M |
| | E Nyika & S Province 9-12&2-4 Z (Collins) | Collins |
| Calleagris hollandi (Butler, 1897) | E Nyika 8-10 | G |
| Calleagris jamesoni jamesoni (Sharpe, 1890) | MNP Nk 9-10&12 Nyika Ruo | G M D |
| Caprona pillaana Wallengren,, 1857 | Monkey Bay Mul Thyolo Zomba 12-3 | G |
| Celaenorrhinus bettoni Butler, 1902 | Mug 5-6 | M |
| Celaenorrhinus galenus biseratus Butler, 1888 | Km3CTO 3 LiwNP Mangochi 11-5 Ruo 4-5&10-11 | G M Du |
| Celaenorrhinus galenus opalinus Butler, 1900 | Minunu hut 9 Mug 6 | M |
| Celaenorrhinus handmani Collins & Congdon, 1998 | Zomba | Collins |
| Celaenorrhinus zanqua Evans ,1937 | Nyamkhowa 9-10&2 | G |
| Eagris notoana notoana (Wallengren, 1857) | Luchenza Mul 12&5 Ruo 2 | G M |
| Eagris sabadius ochreana Lathy 1901 | Nyamkhowa Mul Thyolo Zomba | G |
| Eretis djaelaelae (Wallengren, 1857) | Dedza Juniper 10-12 Liv'tonia 4-5 | G M |
| Eretis herewardi herewardi Riley, 1921 | Thyolo 12 | G |
| Eretis melania Mabille, 1891 | CF 7 Nyamkhowa Manchewe Mug 5-6 Ntchisi 3 Ruo 9-10 | G M |
| | Zomba 7-9 12-2 | |
| Eretis sp cf djaelaelae (Wallengren, 1857) | Dz 1 Km30C-J 8 | M |
| Eretis umbra nox Neave, 1910 | Zomba Collins | |
| Gomalia elma elma (Trimen, 1862) | LiwNP Matipa 12 Monkey Bay Mul Nyika 7 Thyolo 12-1 | G M Du |
| Leucochitonia levubu Wallengren, 1857 | Kazuni 2 Nsanje 9 | G M |
| Netrobalane canopus (Trimen, 1864) | Bt LNP Manchewe 7-10 Nk 7 | G M D |
| Sarengesa astrigera Butler ,1894 | Bt Chikala 2 Dz 1 Malidade-Mpherembe Rd 8 Lilongwe | G M |
| | Nk 10 Zomba 1-4 | |
| Sarengesa haplopa Swinhoe, 1907 | | C |
| Sarengesa lucidella (Mabille, 1891) | Kazuni 3 Nyika Mul 5 Uyuzi 3 | G M |
| Sarengesa maculata (Mabille ,1891) | Bandawe Fort Lister 6 Lik 12 Mug 5-6 Ntchisi 3 Luchenza | G M |
| | Zomba | |
| Sarangesa motozi (Wallengren, 1857) | LNP Lik 12 Nk 3-4,9,10,12 MGR Mt Man 4 Ruo 9-10 | G M D |
| Sarengesa phidyle (Walker, 1870) | Mul 5-7 Nk 10 | G M |
| Sarengesa ruona Evans, 1937 | LiwNP Ruo 4-6 | N Du |
| Sarengesa seineri seineri Strand, 1909 | Liv'stonia Monkey Bay 9 Uyuzi 3 | G M |
| Spialia abscondita (Plotz, 1884) | Mt Mangoche Mul 9&12-3 | G |
| Spialia confusa Evans, 1937 | Nyassaland | G |
| Spialia delagoae (Trimen, 1899) | Delagoa Bay | G |
| Spialia depauperata depauperata (Strand, 1911) | | C |
| Spialia diomus diomus (Hopffer, 1855) | Mul (Collins) | C |

| Species | Site | Person |
|---|---|---|
| Spialia dromus (Plotz, 1884) | Crater 4 KR 3 Lik 12 MNP Mug 6 Nk 1 Ntchisi 3&5 | G M D |
| | Ruo 10-11 Uz 2 Zomba Plat 2 | |
| Spialia mafa mafa (Trimen, 1870) | Juniper 9-11 Ruo 4-7 | G M |
| Spialia secessus (Trimen, 1891) | | C |
| Spialia spio (Linnaeus, 1764) | Juniper 8 Kachere 5&9 Mpat 4&6-7 Mpindika 7 Mug 6 | G M |
| Tagiades flesus (Fabricius, 1781) | Mt Choma 6 Kalwe 4-5 LiwNP MNP Mug 5-6 Nk 5 | G M D Du |
| | Ruo 9-10 Zaro 2 Z (Collins) Shire Highlands Plateau | |
| Xanthodisca vibius (Hewitson, 1878) | Kalwe 7 Nkhata Bay Closed forests 4-5 | G M |
| | | |
| **PAPILIONIDAE** | | |
| | | |
| **Graphium** | | |
| angolanus angolanus (Goeze, 1779) | Chiweta 1 Kahango R. 9 Kas 12 Lik 12 Mkw 11 Ruo 9-10 | G M |
| antheus (Cramer, [1779]) | Choma Mt 12 Lik 12 MGR 11 | G M |
| colonna (Ward, 1873) | Ruo - Seen only | G M |
| leonidas leonidas (Fabricius, 1793) | Mkw 11 Ruo 10-11 Uledi 7 All lower areas 11-6 | G M |
| philonoe (Ward, 1873) | Mzeze 2 | G |
| policenes policenes (Cramer, [1775]) | Crater 8-11 Dz 11 J 12 Mkw 10 Mug 12 Ruo 9-10 | G M |
| polistratus (Grose-Smith, 1889) | Mkw 10-11 Nkhata Bay Lakeshore forests | G M |
| porthaon porthaon (Hewitson, 1865) | Bt Mkw 10-11 Monkey Bay Mpat 5 Ruo 10 Nsanje 7-2 | G M |
| taboranus (Oberthur, 1886) | N.Lakeshore Mul | G |
| tynderaeus (Fabricius, 1793) | Doubtful record Mug 12 | Joly |
| | | |
| **Papilio** | | |
| constantinus Ward, 1871 | Lichenya 2 Limbe Monkey Bay Mpat 11 Mul Nsanje 10-12 2-6 | G M |
| dardanus tibullus Kirby, 1860 | All areas and altitudes throughout | G M |
| demodocus demodocus Esper, [1798] | All areas and altitudes throughout | G M |
| desmondi usambarensis Kokak, 1980 | Mug 2, 5&11-12 | M |
| desmondi ? | Uz 12-2 | M |
| echerioides shirensis Hancock, 1987 | Crater 5 Ndirande 4&6 Thyolo Zomba 10-11, 3-4 | G M * |
| fuelleborni fuelleborni Karsh ,1900 | Misuku Hills 11-5 | G M |
| jacksoni nyika Cottrell, 1963 | Juniper 7&11 Mt Uzumara 11 ZCF 12 | G M * |
| mackinnoni isokae Hancock, 1984 | Chowo 5 Jembya 12 Juniper 9 Kaperikeze 7 Kasyauli 5 | M |
| | Mafinga Mtns 4 ZCF 12 | |
| nandina Rothschild & Jordan, 1901 (Not a true species) | Chiradzulu Mtn Katumbi Forest Nyika NP 5 – Seen on Nyika | M |
| nireus lyaeus Doublday, 1845 | All areas and altitudes throughout | G M |
| ophidecephalus mkuwadzi Gifford, 1961 | Kas 1 Mug 11 Uz 2 Northern evergreen forests | G M |
| ophidecephalus nyassicola Storace, 1955 | Crater 10 Dedza 1,4,6,11-12 Ndirande 3&11 Ruo 9-10 | G M * |
| pelodurus pelodurus Butler, 1896 | Ruo 10-11 Z 3-4, 7-9 Southern evergreen forests 8-6 | G M |
| pelodurus vesper Le Cerf, 1924 | Kas 12 Mug 1-2 Uz 12 Northern evergreen forests 8-6 | G M |

| Species | Site | Person |
|---|---|---|
| phorcas nyikanus Rothschild & Jordan, 1903 | Crater 9 Ruo 4 Mafinga 4 Mug 12 &2 Uz 12 | G M |
| thuraui cyclopis Rothschild & Jordan, 1903 | Chowo 5 Nyamkhowa 11&3 Uzumara 11-5 | M * |
| thuraui occidua heathi Hancock, 1984 | Ndirande 3-4&11 Mul 2, 6, 9-11 Zomba 2-3, 6-10&12 | M * |
| thuraui occidua ? | Dedza 2-3, 5 6-8 | M * |
| thuraui occidua ? | KR 3-4 | M * |
| thuraui occidua viphya Hancock, 1984 | Chikangawa 4 Mzuzu 4&12 | M * |
| thuraui thuraui Karsch, 1900 | Misuku Hills 10-5 Uz 12 (Joly) doubtful | M |
| | | |
| **PIERIDAE** | | |
| | | |
| Afrodryas leda (Boisduval, 1847) | Chikwawa 5 Chipoka 5 Mangochi 5 | G M |
| Appias epaphia contracta (Butler, 1888) | Ft Lister 6 Lik 12 MGR 5 Mt Malawi 5 Mug 12 Nk 5-6 | G M |
| | Monkey Bay Ruo 5&9-10 | |
| Appias sabina phoebe (Butler, 1901) | Crater 10 Kas 12-1 Mt Malwi 10-11&3 Mug 6&12 Ruo 10-11 | G M |
| | Thyolo Mkw 11 observation by Joly not substantiated | |
| Appias sylvia nyasana (Butler, 1897) | N Malawi Thyolo 4 (Wood) | G |
| Belenois aurota aurota (Fabricius, 1793) | Ft Lister 6 Kuche 5 Mug 6 Nk 5-6 Rumphi 4 Uledi 7 Uz 4 | G M |
| Belenois calypso welwitschii Rogenhoffer, 1890 | | L |
| Belenois crawshayi Butler, 1894 | E Nyika Karonga | G |
| Belenois creona severina (Stoll, [1781]) | Choma 7 Mt Malawi 5 Mug 2 Nk 5-6&9 All areas throughout | G M |
| Belenois gidica abyssinica Lucas, 1852 | Chikala Lik 12 Mug 12 Nk 5&7 Zomba 2-5, 7, 9 | G M |
| Belenois rubrosignata kongwana Talbot, 1943 | Chipome 7 Juniper 9 Kas 12 Kawiya 8 Mwasizi 8 Mul Mug 4 | G M |
| | Ngapani 5 | |
| Belenois thysa thysa (Hopffer, 1855) | Manchewe 11 Nsanje | G M |
| Belenois zochalia agrippinides (Holland, 1896) | Choma 6 Juniper 9 Karonga Kas 12 Nk 12 Uledi 7 S Lakeshore | G M |
| Catopsilia florella Fabricius, 1775 | Govati 2 Mpat 1 Ntchisi 11-12 Nyika T All areas throughout | G M |
| Colias electo hecate Strecker, 1900 | Mt Choma 1&6 Misuku Hills Nyika Mt Uzumara 2-4 | M |
| Colias electo murphyi Verhulst, 2009 | Chambe 5 Minunu 5&9 Ruo 2 Zomba 2&5 | M * |
| Colias mukana jolyi Verhulst, 2009 | KR 3-4 Mt Lwnjati 2&4 | M * |
| Colotis annae annae (Wallengren, 1957) | Chikwawa 5 Kahango River 9 Kawiya 8 Malidade 8 Rumphi 12 | G M |
| | Mangochi Monkey Bay Florence Bay | |
| Colotis annae hilderbrandti (Staudinger, 1885) | Karonga Likoma 4-5 Mug 6 Rumphi 12 | G M |
| Colotis antevippe gavisa (Wallengren, 1857) | Chikwawa 5 Choma 8 Kahanga River 9 Kawiya 8 | G M |
| | Lunyangwa swamp 6 Malidade 8 Mpat 1 Nk 4-6 | |
| Colotis aurigineus (Butler, 1883) | Luwawa 2 Nk 1&4-7 Dry deciduous woodland in N Malawi | G M |
| Colotis calais Cramer, [1775] | Liw NP Mangochi Swamp 5 Monkey Bay MGR 5 Liw NP | G M |
| | Nsanje 10-3 & 5-7 | |
| Colotis celamene celamene (Lucas, 1852) | Bt 4 Makanjila 5 Monkey Bay Mpat 2-3 Nsanje 2-9 Rumphi 12 | G M |
| Colotis auxo dissociatus (Butler, 1897) | Balaka Chikwawa 5 Ft Lister 6 LMNP 5 Likoma Malidade 8 | G M |

| Species | Site | Person |
|---|---|---|
| | Mangochi swamp 5 Monkey Bay 5 MGR 5 Mzimba Nk 4&6 | |
| | Rumphi 4 Uz 4 | |
| Colotis evagore antigone (Boisduval, 1836) | Chikwaw 5 Henga Valley Kalindamawe 8 Mpat 4 MGR 5 | G M |
| | Ndirande 4 Nk 4-5 Uledi 7 | |
| Colotis evenina casta (Gerstaecker, 1871) | Kahango River 9 MGR 5 Ngapani 5 Rumphi 4&12 | M |
| Colotis evippe omphale (Godart, [1819]) | Chikwawa 5 Duduzu 5 Mpat 3 MGR 5 Mug 6 Nk 4-5 Rumphi 4 | G M |
| Colotis ione (Godart, [1819]) | Bangula Chikwawa 5 Monkey Bay Mangochi Mpat 3-4 MGR 5 | G M |
| | Nk 5 SBFR 3 | |
| Colotis pallene (Hoppfer, 1855) | Chikwawa 5 Kawiya 8 Kazuni 10 Malidae 8 Man Swp 5 Mpat 2 | G M |
| | MGR 5 Nk 9 | |
| Colotis regina (Trimen, 1863) | Chawezga 8 Mpat 3&5 MGR 5 Ngapani 5 Nsanje Rumphi 4 | G M |
| | Zaro 2 | |
| Colotis vesta mutans (Butler, 1877) | Bt 4 Makanjila 5 Mpat 2-3 Rumphi 12 | G M |
| Dixea doxo parva Talbot, 1943 | Barra 5 Chipoka 5 Man swamp 5 Monkey Bay 2-5 | G M |
| Dixea leucophanes ? Vari, 1976 | Man Swamp 5 | M |
| Dixea indet | Rumphi 4 | M |
| Dixea orbona vidua (Butler, 1900) **or form of pigea ?** | Nk 5-7&9 | M |
| Dixea pigea (Boisduval, 1836) | Mt Malawi 5 Nk 3-5&7 Medium & lower atitudes 4-6 | G M |
| Eurema brigita brigita (Stoll, [1780]) | J 10-11 Kahango Riv 9 Kalindamawe 8 Kalwe 8 KR 4 Mpat 2 | G M |
| | Muchiru 3 Mug 1 MGR 5 Nk 6&9 Uz 4 | |
| Eurema desdarjinsi marshalli Butler, 1898 | J8 Kalwe 6 KR 4 Lunyangwa sw 4 Mbowe Dam 4 Mug 2-3&6 | G M |
| | Nganda 7 Nk 1,3,5-6 Uz 2&4 Zaro 2 | |
| Eurema floricola orientis Butler, 1888 | Kalwe 6 Ruo 9-10 | M |
| Eurema hapale (Mabille ,1882) | Kasyauli forest 5 Lunyangwa sw 5-6 SBFR 3-4 | G M |
| Eurema hecabe solifera (Butler, 1875) | K Gate 7 Kas 1 Km9T 2 Muchiru 4 Mug 6 Nk 1,5-6&9 Uz 2 | G M |
| | Zaro 2 | |
| Eurema mandarinula Holland, 1892 | CF 8 J 7&10 K Gate 5 Miniunu Hut 9 Uz 12 | G M |
| Eurema regularis Butler, 1876 | KR 4 Lik 12 Nk 4-6&9 | G M |
| Eurema senegalensis (Boisduval, 1836) | K Gate 5 Mug 11-1&6 Nk 1&5-6 Ruo 9-10 | G M |
| Eurema indet 1 – upembana? Berger, 1981 **to be confirmed** | Chambe 5 Kalwe 6 Kasyauli f 5 Nganda 3 Nk 6 Uz 2&4 | M |
| Eurema indet 2 | Chowo 1 Kas 12 Mug 2 Uz 2-4 | M |
| Eurema indet 3 | CF 7 Choma 6 Nk 6 | M |
| Eurema indet 4 | Nk 6 | M |
| Leptosia alcesta inalcesta Bernardi, 1859 | Mt Malawi 5 Nk throughout Ruo 5&9-10 | G M |
| Mylothris agathina agathina (Cramer, [1779]) | Chis 5 Kajalirwe river 6 Kuche 5&9 Mug 6 Nk 5 Ntchisi 5 | G M |
| | Uzuzu 5 | |
| Mylothris crawshayi crawshayi Butler, 1896 | Chowo 5 Juniper 7&9 Nyika 4 Kaseramba 12-1 Kasyauli 5 | G M |
| Mylothris rubricosta attenuata Talbot, 1944 | Liwonde Lunyangwa swamp 4,6&10 Zomba 3-7 | G M * |

| Species | Site | Person |
|---|---|---|
| Mylothris rueppellii rhodesiana Riley, 1921 | Chikangawa 4 Ifisa 4 Juniper 9 Kasyauli 5 Km9T 2 Kuche 4-5 | G M |
| | Luwawa 2&5 Nk 3,5&9 Uzuzu 5 | |
| Mylothris sagala dentatus Butler, 1896 | Dedza 2-3 J 11 KR 4 Mug 5-6 Ndirande 4 Ntchisi 3&11-12 | G M |
| Mylothris sagala seminigra ? Talbot, 1944 | Mt Man 4 | M |
| Mylothris similis similis Lathy, 1906 | Chis 1-2 Mul Soche Mtn Thyolo Mtn Zomba Mtn 1-3 9-11 | G M |
| Mylothris yulei yulei Butler, 1897 | Chisasira 1-2 Kuche 5 Ruo 9-11 Songwe 8 | G M |
| Nepheronia argia mhondana (Suffert, 1904) | Kaseramba 1 Mpat 7 Mt Man 4 Ntchisi 3 Ruo 9-10 | G M |
| Nepheronia buqueti buqueti (Boisduval, 1836) | Liw NP Lower Shire | G |
| Nepheronia thalassina sinalata (suffert, 1904) | Nkata Bay Ruo 9-10 Uledi 7 | G M |
| Pinacopteryx eriphia eriphia (Godart, [1819]) | Brachystegia woodland 12-6 | G M |
| Teracolus eris eris (Klug, 1829) | Mpat 4 Uledi 7 Uzuzu 3 | G M |
| Teracolus subfasciatus ducissa (Dognin, 1891) | Chiromo Kahanga River 9 Mwasizi 8 Mzimba Mpat Nsanje | G M |
| | Rumphi -5&8 | |
| | | |
| **NYMPHALIDAE** | | |
| | | |
| **Danainae** | | |
| Amauris albimaculata latifascia Talbot, 1940 | Mul Nyika 4-6 9-10 | G |
| Amauris crawshayi crawshayi Butler, 1897 | Chis 1 Kajalirwe River 6 Nk 12&3 Songwe 3-8 | G M |
| Amauris echeria serica Talbot, 1940 | Chikangawa 5 CF 7 Kajalirwe River 6 Mug 12-1 Ntchisi 12 | G M |
| | Nyamkhowa 10-3 Uz 12-2 | |
| Amauris echeria whytei Butler, 1894 | Chikala KR 4&10 Mt Malawi 5 Mt Man 4 Ntchisi 11-12 | M * |
| | Zomba 2-3&5 | |
| Amauris ellioti junia (Le Cerf, 1920) | Mt Dedza 3 Kaseramba 12 Mug 12&5 Uz 12-1 | G M |
| Amauris niavius dominicans Trimrn, 1879 | Mt Malawi Mug 6 Nkhata Bay forests Zomba | F G M |
| Amauris ochlea bumilleri Lanz,, 1896 | Songwe 1 | G |
| Amauris ochlea ochlea (Boisduval ,1847) | Mt Malawi 5&10 Mul Zomba 2-4 | G M |
| Amauris tartarea damoclides Staudinger, 1896 | Kalwe 4 &8 Mug 1&4-5 Nk 2 Mul? Nkhata Bay 4-6&11 | G M |
| Danaus chrysippus aegyptus (Schreber, 1759) | All areas throughout | F G M |
| Tirumala formosa formosa (Godman, 1880) | Chikangawa 3 CF 7 Mug 11 | M |
| Tirumala petiverana (Doubleday, [1847]) | Manchewe Nkhata Bay Songwe Wenya 1,3,5 & 8 | G M |
| | | |
| **Acraeinae** | | |
| Genus **Acraea** | | |
| acara (Hewitson,1865) | KR 11 Mpat 2 Namitembo 9 Nk 12 Ruo 9-10 Uzuzu 2 | B G M |
| acerata Hewitson, 1847 | Kalwe 5 Mwazisi 5 N Bay 3 | B G M |
| acrita Hewitson, 1865 | Choma Mt 5 KR 5 Km3T 10 Km5T 10 Ntchisi 2&5 Ruo 2&9 | B G M |
| acuta Howarth, 1969 | Chowo 5 J 8 Kasyauli 5 Mug 2, 4-6, 11 | M |
| aganice aganice Hewitson, 1852 | KR 4 Mt Malawi Mt Man 4 Ruo 2 Thyolo Zomba 3-5 | B G M |
| aganice montana (Butler, 1888) | Choma Mt L'stonia Mkw 9 Mug 12 Ntchisi Uz Uledi | B F G M |

| Species | Site | Person |
|---|---|---|
| | 7 | |
| anacreon Trimen, 1868 | CF 4 J 10 Kas 12-1 KR 4&10 Km3T 10 Km8CTO 11 | B F G M |
| | Km24T 10 Lik 12 Luwawa 4 Minunu 9 Mug 12-1,5-6 | |
| | Ndirande 4 Nk 9-10 Ntcheu 3 Ntchisi 5 Sonjo 2 | |
| anemosa Hewitson, 1865 | Bt 1 Govati 2 Kazuni 10 Mondwe 4 Mpat 11 Thumbi Sch 10 | B G M |
| | Chikwawa Manchewe Mangochi Mpat Mul Z | |
| asema Hewitson, 1877 | KR 4&8 Malosa FR 8 | B M |
| atergatis Westwood, 1881 | MGR | D |
| axina Westwood, 1881 | Bt Chikwawa Chitipa Lil Mpat SBFR 3 Shire Valley | B G M |
| baxteri Sharpe, 1902 | CF Misuku Hills | G |
| bonasia (Fabricius, 1775) | Kaporo Rd 12 | M |
| boopis choloui Pierre, 1979 | Bangwe Chiradzulu 2 Mt Malawi Mpingwe Mt Soche Thyolo5 | B G M * |
| burni (Butler, 1896) | Mt Malawi Mt Mangochi Mt Tsenga 3-4 Zomba Plat | G M |
| cabira Hopffer, 1855 | Chis 5 Crater 5,8-9 Lunyangwa sw 6 Nk 10 Ntcheu 3 Ntchisi 5 | B F G M |
| | Ruo 3-5, 7, 9-10 | |
| calderena Hewitson, 1877 | Govati 1 J 9 KR 8&11 Km5T 10 Malosa FR 8 Mangochi 5 | B G M |
| | Mpat 1 Uledi 7 | |
| cephus bergeriana Pierre ,1979 | Mug 2, 6, 11-12 | B M |
| cerasa cerasa Hewitson, 1861 | Chigwi's Hole 2 KR 11 Mt Man 4 | M |
| cerasa cerita Sharpe, 1906 | Mug 5&11 | M |
| curva Grose-Smith, 1889 | Monkey Bay Nsanje | G |
| egina egina (Cramer,[1775]) | Crater 11 KR 3-4 Mug 6 Ruo 3, 6, 9-10 | B G M |
| encedon (Linnaeus, 1758) | Kalwe 5 Kuche 7 Lik 4 Nsanje 6 Ntchisi 5 Nyam 12 Mug 6 | B F G M |
| epaea melina (Thurau, 1903) | Chinteche Crater 5 Kalwe Mkw 9-10 Mug 12 Ruo | B G M |
| esebria Hewitson, 1861 | Crater 5&8 Kalwe 5 KR 4 Limbe 8 Ntchisi 3 Ruo 5-6 | B G M |
| goetzei Thurau, 11903 | CF 8 Crater 8 Dedza J 10 Kas 12-1 Km 3T 10 Km8CTO(Z) 10 | B F G M |
| | Km30C-J 3 | |
| | Mitchiru Mtn Mug 5-6 Nganda 4&7 Ruo 4&9-10 Uz 4 Z 3&6 | |
| igola Trimen, 1889 | Lichenya hut Lik Ruo 1 Thyolo 4 | B M |
| insignis Distant, 1880 | Lichenya hut Kas 12 Mug 5 Mul Nyam Ruo 2&7 Uz 1 Wilindi | B G M |
| johnstoni johnstoni Godman 1885 | Mug 5-6&12 Ruo 2,4-6,9-10 Thyolo 4 Uz 1 Z | B G M |
| leucopyga Aurivillius, 1904 | CF 8 Km5T10 Lik Malosa FR 8 Mangochi Mt 5 Nkotakota GR | B G M * |
| | Ntchisi Uzuzu 5 | |
| lyci Pierre, 2006 | Ifisa Hill 4 Nyamkhowa | G M |
| machequena Grose-Smith, 1887 | Mul Mitsidi Hill Nsanje Thyolo 5-7 12-1 | G |
| natalica Boisduval, 1847 | Bt 1 Crater 8 Mt Mal 10 Mt Man 4 Mug 6&12 Nk 12 Nyam 12 | B G M |
| | Ruo 4&9-10 Rumphi 12 Z 4 | |
| neobule neobule Doubldaey [1852] | Bt Chambe Plat 5 Chikwawa Dedza 5 Ft Lister 4 Ifisa 4 | B G M |
| | Kalindamawe 8 Kalwe Kazuni 1 KR SBFR 3-4 Thyolo FR 4 | |

| Species | Site | Person |
|---|---|---|
| | Tsenga Mt 3-4 Uyuzi Z | |
| oncaea Hoppfer, 1855 | Bt 1 LMNP Lik 4-5&12 Mt Mal 2&10 Malosa Fr 8 Mkw 3 | B F G M |
| | Mt Man 4 Monkey Bay 4 Mpat 1-3&7 Tsenga Mt 4 Uledi 7 Z 2-3 | |
| pentapolis epidica Oberthur, 1893 | Lichenya hut Mt Man 4 Mpingwe Mug Ruo 10-11 Soche | B G M |
| | Thyolo 5 Z 3 | |
| perenna | Doubleday, [1850] Bugulo Mtn 5 Chis 5 Mkw 4&10 Mug 5 | B F G M |
| periphanes Oberthur, 1893 | Bugulu Mt Choma Mt Dunduzu 7 Dz Ifisa 4 Kas 12 Km3T 10 | B M |
| | Km8CTO(Z) 11 Mazamba Nk 4.6.12 Uledi 7 | |
| petraea Boisduval, 1847 | Mzeze 3 | G |
| pharsalus Ward, 1871 | Bt Chis 4 Choma Mt Kalwe Mt Man 4 Matipa 12 Mug 5 Ruo | B G M |
| | Thyolo Mt 5 | |
| pudorella detecta Neave, 1910 | Chitipa Malidade 8 Uledi 7 VMGR | B G M |
| punctellata Eltringham, 1912 | Dedza Mt 4-6 Ft Lister 4 KR 8&11 Lichenya Hut | B G M |
| | Nkhota Kota GR Ntchisi Thyolo Zomba Plat 3-5 | |
| quirina (Fabricius, 1781) | Chiradzulu 2 KR 4 Mt Malawi 11-3 Thyolo Mt 5 | B G M |
| rabbaiae perlucida Henning & Henning, 1996 | Thyolo | B |
| rahira rahira Boisduval, 1833 | Thyolo | B |
| rahira mufindi Kielland, 1990 | Lunyangwa sw 1&4-5 | B M |
| scalivittata scalivittata Butler, 1896 | Kas 1 Kasyauli f 2 ZCF | D F M |
| serena Fabricius, 1775 | Choma Mt 2&4 J Minunu Hut 5 Mpat 2&4 Mug 6 Ntchisi 3&5 | B F G M |
| | Ruo 5 Uledi 7 | |
| sotikensis Sharpe, 1891 | K Gate 7 Mug 5-6 | B M |
| ventura Hewitson, 1877 | Choma Mt Dedza Mt Kalwe Km3T 10 Lichenya hut | B F G M |
| | Lunyangwa swLuselo R Ruo T Gate Mug 1-2&6 Nganda 6 Uz | |
| | ZCF Z Plat | |
| vumbui Stevenson, 1934 | Crater 2 Mug 4-5 Ndirande 2 Ruo 4-5,8&10-11 Thyolo Mt | B F G M |
| zetes (Linnaeus, 1758) | Chisasira 1 Kalwe 1 Nkw 1 Kaporo L'stonia 4 Mug ZCF | B M |
| zonata Hewitson, 1877 | Mzeze 3 | G |
| Genus **Pardopsis** | | |
| punctatissima Boisduval, 1833 | Chim 2 Kalwe Kasn12-1 KR 4 Kawiya 8 Lik 12 MGR 4 | B G M |
| | Nganda 8 Nkhotakota GR Ntchisi SBFR Uz Uzuzu Z Plat | |
| **Satyrinae** | | |
| Aphysoneura pigmentaria latilimba Le Cerf, 1919 | Ruo4-6, 9-10 | G M * |
| Aphysoneura pigmentaria obnubila Riley, 1923 | Juniper 3,7 &12 Mt Uzumara 2-3 Mug 1&4-6 | M * |
| Bicyclus angulosus selousi (Trimen, 1895) | Kalindamawe 8 Kawiya 8 Kazuni 12 Malosa 8 Nk 10 Ntchisi 3 | G M |
| | Uyuzi 3 | |
| Bicyclus anynana anynana (Butler, 1879) | Kalwe 5-6 Malosa 8 MGR 5 Nk 9-10 Ntchisi 3 E Nyika | G M |
| | Ruo 5-6 Shire Valley 8-10 Uledi 7 | |

| Species | Site | Person |
|---|---|---|
| Bicyclus campina campina (Aurivillius, 1901) | Chagwa 8 Crater 8 Kalwe 5 Malosa 8 Mkw Mul Mug 5& 12 | G M |
| | Nk 9-10 Ntchisi 2 E Nyika 3 7 9 12 | |
| Bicyclus cottrelli (Van Son, 1952) | Chagwa 8 Kalindamawe 8 Mangochi Mul 6 Nk 10 Ntchisi 3&5 | G M |
| | Uledi 7 | |
| Bicyclus ena (Hewitson, 1877) | Bt Kalindamawe 8 Kawiya 8 Lik 12 LMNP 5 Malosa 8 | G M |
| | Manchewe Mangochi Ntchisi 3 | |
| Bicyclus safitza safitza (Westwood, [1850]) | Kalwe 6 LMNP 5 Malosa 8 Mpat 7 Nk 10 Uledi 7 | G M |
| Bicyclus simulacris simulacris Kielland, 1990 | Chowo 5 Km3CTO 3 Uz 2 | M |
| Bicyclus vansoni Condamin, 1965 | | C |
| Gnophodes betsimena diversa (Butler, 1880) | Kalwe 6 Mkw 5 Ntchisi 11-12 | G M |
| Henotesia perspicua (Trimen, 1873) | Kalwe 6&8 Lik 12 Malosa 8 Ntchisi 3&5 Ruo 5 Uyuzi 3 Uz 2 | G M |
| Henotesia simonsii (Butler, 1877) | Mpat 6 Mug 12 Nk 9-10 Uledi 7 | G M |
| Henotesia ubenica ubenica Thurau, 1903 | J 9-10 Luwawa 1 Mug 2 &12 Uz 2&4 | G M |
| Melanitis leda helena (Westwood, [1851]) | Bvumbwe KR 4 Kuche 5 Lik 2-4 Muchiru 6 Nk 6 Ruo 5 Zaro 2F | GM |
| Melanitis lybia Distant, 1882 | Chambe Choma 6 Crater 5 Mt Mal N Bay closed forests Nznje | FGM |
| | Mt Thyolo Uzuzu 4 Mt Zomba 3-6 | |
| Neocoenyra bioculata Carcasson, 1964 | Mt Tsenga 2&4 | M * |
| Neocoenyra bioculata murphyi Collins | KR 4 Mt Man 4 | M * |
| Neocoenyra gregorii Butler, 1894 | KR 4 L'stonia Mug 2&6 Mul Ndirande 4 Nganda 3 Nk 3&6 | G M |
| | Ntchisi 3 Mt man 4 Uz | |
| Neocoenyra kivuensis Seydel, 1929 | | C |
| Neocoenyra ypthimoides Butler, 1894 | Mt Man 4 Mul Plat Zomba Plat | G M |
| Physcaeneura pione Godman, 1880 | Ft Man 4-5 KR 3-4 Lik 12 Vint 11 | G M |
| Ypthima asterope asterope (Klug, 1832) | Deciduous woodland of plateau and lower levels | G |
| Ypthima condamini condamini Kielland 1982 | Kalindamawe 8 KR 4 Kawiya 8 Km24T 7 Lik 12 Muchiru 3 | C M |
| | Nk 9 Uz 4 | |
| Ypthima granulosa Butler, 1883 | Chim 3 Kalwe 8 Mug 6 Mul Ntchisi 2 Songwe 8 | G M |
| Ypthima impura Elwes & Edwards, 1893 | Manchewe Mul 12-5 | G |
| Ypthimomorpha itonia (Hewitson, 1865) | Lun swp 4 Muchiru 3 Mul E Nyika 9-11 2-5 | G M |
| | | |
| **Argininae** | | |
| Issoria smaragdifera smaragdifera (Butler, 1895) | Chambe Kas 12-1 Nganda 4 Minunu 9 | F G M |
| Lachnoptera ayresii Trimen, 1879 | Mt Malawi Ruo 9-11 Mt Thyolo 2-5&12 | G M |
| | Nkata Bay closed forests | |
| Phalanta phalantha aethiopica (Rothschild & Jordan, 1903) | Kalwe 6 Kas 1 Nganda 3 Nk 5-7 Ruo 3 | GM |
| | | |
| **Charaxinae** | | |
| Genus **Charaxes** | | |
| achaemenes achaemenes Felder & Felder, [1867] | Chambe 5 Crater 8&11-5 Dz 4 Kuche 5 Lik 11-5 MGR 5 | F G M |
| | Mpat 9&12 Nk 5-6 Ruo 11-5 Z 3-9 | |

| Species | Site | Person |
|---|---|---|
| acuminatus acuminatus Thurau, 1903 | Mug 11 | G M |
| acuminatus mlanji van Someren, 1963 | Crater 10-4 KR 3-4 Kuche 9 Lich Plat 12 Ruo 10-5 | G M * |
| | Zomba 6-8&10 | |
| acuminatus nyika van Someren, 1963 | Nk 6 Nyam 3 | G M * |
| ameliae amelina Joicey & Talbot, 1925 | Blantyre Chis 4-5 J 9 Kalwe 5 Mkw 5&10 Nk 5-7 | G M |
| ansorgei levicki Poulton, 1933 | Kas 12 Mug 11&4 -5 | M |
| aubyni australis van Someren & Jackson, 1957 | Crater 11&5 KR 11 Lich Plat 12 Lik 12 Ntchisi Ruo 11,1&5 | G M |
| | Z 3-11 | |
| baumanni whytei Butler, 1894 | Dedza 6 E Nyika Zomba 1-12 | G M |
| bohemani Felder & Felder, 1859 | Crater 8&11-4 Dz 4 KR 4 Lik 12-4 Nk 6 Ruo 11-5 Z 3-11 | G M |
| brutus natalensis Staudinger, 1885 | Crater 8&11-5 Lik 12-4 Nk 4-6 Ntchisi 3 Ruo 11-6 Z 1-12 | G M |
| candiope candiope (Godart, [1824]) | Crater 5-6 Dz 4-5 Kuche 5 Ruo 9-12 Mug 4-5&11 Nk 5-7 | G M |
| | Uz 5 Z 2-12 | |
| castor flavifasciatus Butler, 1895 | Mkw 10 Mpat 1 Mug 5 Nk 5-6&9 Ruo Z 5-12 | G M |
| castor x jasius | Mpat 4 | M |
| chinteche van Someren, 1975 | Chis 5&12-1 Kalwe 2&5 Mkw 5&10 Nk 2 | G M |
| cithaeron nyasae van Someren, 1964 | Chis 5 Crater 5-6,8&10 Kalwe 5-6 LMNP 4 Ntchisi Mkw 10 G M | |
| | Nk Ruo 4-10 Z 1-12 | |
| dowsetti Henning, 1989 | Chelinda 12-3 Kas 12-1 Nyam 11-12 | M * |
| druceanus proximans Joicey & Talbot, 1922 | Crater 11-4 Dz 11 J 12 KR 3 Lik 11-4 Nk 5-6&12 Mkw 10 | G M |
| | Mug 11 Ruo 11-4 Z 6-12 | |
| etesipe tavatensis Rothschild, 1894 | Mangochi Mul (no data) Z 8-9 (Wilson – needs confirmation) | G M |
| ethalion ethalion (Boisduval, 1847) | Mt Malawi 5 | M |
| ethalion handmani Henning, 1982 | Crater 5,8,10-11 KR 4 Kuche 5&7 Litchenya 1 Mpat 3 | M * |
| | Ruo 3-9&11-12 Uzuzu 5 Z 3-12 | |
| ethalion kitungulensis Strand, 1911 | Chis 4-5&12-1 Chowo 5 Kalwe 5 Mkw 10-11 Mug 5 Nk 5-6 | F M |
| fionae Henning, 1977 | Bt 3 Mt Chakala 5 Chis 5&12 Crater 8&10 Dz 4 Kalwe 5 KR 3 | M |
| | Kuche 7 Lik 4 Mkw 15&0 Mtangatanga 12 Muchiru 3&5 | |
| | Mwasizi 8 Nk 3&5-8 Ruo 7-8 Sawi 4 Z 9-10 | |
| guderiana guderiana (Dewitz, 1879) | Chis 5 Crater 5 Dz 4 Ifisa 4 J 12 Kas 12 Kuche 5 Nk 6-8 | G M |
| | Z 3-12 | |
| howarthi ? | **To be verified** Crater 8 Lik 4 | M |
| howarthi Minig, 1976 | CF 4 Dz 4&11 Kalindamawe 8 KR3-4 Kawiya 8 Km19T 1 | M |
| | Nk 4-10&12 | |
| jahlusa argynnides Westwood, 1864 | Mpat 1-2,4-5 MGR 5 Liw NP 2 Z 10 | G M |
| jasius saturnus Butler, 1866 | Chinongo R (Misuku) 5 Mpat 12-1 Muchiru 6&9 MGR 5 | G M |
| | Ruo 11 Z 6-11 | |
| macclounii Butler, 1895 | Crater 8&11-5 Lik 11-4 Mug 12 Ruo 10-5&9 Z 2-12 | G M |

| Species | Site | Person |
|---|---|---|
| manica Trimen, 1894 | **To be verified** Mpat 3-7 Muchiru 3 Tsenga Mtn 4 | M |
| margaretae Rydon, 1980 | Crater 10 & Ruo 4-7&10 | M * |
| martini helenae Hening, 1982 | Kuche 6, 8&10 Zomba 8 | M * |
| martini martini van Someren, 1966 | Crater 8-10 Lik 9 Ruo 8&10 | M * |
| nichetes leoninus Butler, 1895 | Chis 5 Crater 10-4 KR 4 Kuche 5 Lik 12-4 Mkw 11 Nk 6 | G M |
| | Ruo 10-4 Z 2-11 | |
| nyikensis van Someren, 1975 | Kas 12 Kasyauli 5 Mug Mt Uzumara 1 | M * |
| penricei tanganyikae van Someren, 1966 | Bunganya 1 Mt Chakala 5 Chis 5 Crater 8 Mpat 6 Nk 6&8 | G M |
| | Ntchisi 5 | |
| phaeus Hewitson, 1877 | Mpat 1-4 Muchiru 9 MGR 5 Uledi 7 | G M |
| pollux geminus Rothschild, 1900 | Crater 10-5 Dz 11 Ruo 10-5 Lik 12-4 Nk 5-7&9 Z 1-12 | G M |
| protoclea azota (Hewitson, 1877) | Chis 5 Crater 6-7 Kalwe 5 Kuche 5 Mkw 10 Mpat 6 Nk 2,5-8 | G M |
| | Z 2-12 | |
| pythodorus ventersi Henning, 1982 | Kuche 8 &11 Namitembo | M * |
| varanes vologeses (Mabille, 1876) | Crater 5 Kalwe 5 Kuche 5 Mpat 1 Muchiru 9 Nk 4-7&9 | G M |
| | Ruo 5-6 Z 2-12 | |
| violetta melloni Fox, 1963 | Chis 5 Crater 11-4 Kalwe 5-6 Ruo 11-5 Z 3-11 | G M |
| xiphares ludovici Rousseau-Decelle, 1933 | Kas 12-1&5 Nk 9 Nyam 12 Mug 4&11-12 Uz 4-5 | G M |
| xiphares – Mt Mangochi | Mt Man 4 | M |
| xiphares woodi van Someren, 1964 | Crater 11&5 Kuche 9 Lich Plat 11 Namitembo 8 Ruo 4-6&10-11 | G M * |
| | Thyolo Z 3,5-6&8-9 | |
| zoolina zoolina (Westwood, [1850]) | Crater 8&11 LiwNP 2 Ruo 1,3-5&9-12 MGR 12 Z 5-10 | G M |
| | | |
| Euxanthe wakefeildi (Ward, 1873) | Chis 5 Crater 11 Kalwe 4 Mkw 10-11 Ruo 11 | G M |
| Hypomelaena tiberius tiberius Grose-Smith, 1889 | Mkw 11 | M |
| Viridixes eupale form veneris (White & Grant, 1989) | Chis 5 Kas 12-1 Mug 5 Nk 6-9&12-1 Uz 1 | M |
| Viridixes eupale form kasitu (White & Grant, 1989) | KR 3-4 | M |
| Viridixes dilutus dilutus (Rothschild, 1898) | Crater 5 Ruo 2&5 Zomba 2-12 | G M |
| | | |
| | | |
| **Limentinae** | | |
| Aterica galene theophane Hopffer, 1855 | Kalwe 5 Litchenya 4 Mkw 10 Nk 6 Ntchisi 11-12 | M |
| | Evergreen forests 4-6 10-12 | |
| Bebearia orientis orientis (Karsch, 1895) | Ft Lister 6 Juniper 7 Kalwe 8 Lik Litchenya 2 Mkw 10-11 | G M |
| | Satemwa 2 | |
| Byblia anvatara acheloia (Wallengren, 1857) | Chambe Kas 12-1 KR 4 Mpat 9 MGR 5 | F G M |
| Byblia ilithya (Drury, [1773]) | Thyolo | G |
| Catuna sikorana Rogenhoffer, 1889 | Chis 5 N Bay closed forests 4-6 & 12 | F M |
| Crenidomimas concordia (Hopffer, 1855) | Chelinda Chirumba 5 Chis 5 Kalwe 5 Mul Ntchisi 5 E Nyika | F G M |
| | Uledi 5 | |

| Species | Site | Person |
|---|---|---|
| Cyrestis camillus sublineata Lathy, 1901 | Crater 1,5&10 N Bay Closed for Nk 1&5 E Nyika Ruo 10-11 G M | |
| | Zomba 5-9 11-12 | |
| Cymothoe coranus dowsetti Beaurain, 1988 | KR 3-4 | M * |
| Cymothoe coranus murphyi Beaurain 1988 | Litchenya FR 2-3 Ruo 4-5 | M * |
| Cymothoe cottrelli Rydon, 1980 | Kas 12 Juniper 12 Mug 12 Nyamkhowa 12&2 Uz 2 Willindi 12 | M * |
| Cymothoe melanje Bethune-Baker, 1926 | Crater 2 Litchenya 2 Ruo 3-5&7 | M * |
| Cymothoe sp nova | Mt Man 2-4 | M * |
| Cymothoe zombana Bethune-Baker, 1926 | Mt Zomba 3-4&6 | M * |
| Cyrestis camillus sublineata Lathy, 1901 | Crater 8-10&1 Kuche 8-9 Ruo 10-11 Nk 5 N Bay E Nyika | G M |
| Eurytela dryope angulata Aurivillius, 1898 | Crater 10 Litchenya 4 Nk 7 Ruo 9-10 | G M |
| Eyrytela hiarbas lita Rothschild & Jordan, 1903 | Chiradzulu 2 Kuche 6 Mt Man 4 Mug 6 Nk 7 Thyolo Mtn 5 | G M |
| Euphaedra crawshayi Butler, 1895 | Chis 1&5 Kalwe 5&8 L'stonia WS 12 Mug 1&5-6 Nk 6&8 | M |
| | Uz Z 5 | |
| Euphaedra murphyi Hecq, 1991 | Chis 5 | M |
| Euphaedra neophron neophron (Hopffer, 1855) | Crater 6 Chipoka 4 Chis 5 Kalwe 5 Litchenya 1 | M |
| Euphaedra nigrobasalis ceramica Hecq, 1991 | Chis 5 Kalwe 5 Mkw 5 | M |
| Euphaedra orientalis Rothschild, 1898 | TangadziThicket, Chiromo | G |
| Euptera pluto kinugnana (Grose-Smith, 1889) | Crater 5&10 Ruo 2-3, 8-11 | G M |
| Euriphura achlys (Hopffer, 1855) | Manchewe Mkw Ruo 9-10 Thyolo 2-7 9-10 | G M |
| Harma theobene blassi (Weymer, 1892) | Cape Maclear Chis 5 Chowo 5 Kajalirwe R 5 Kalwe 8 | G M |
| | Namizimu FR E Nyika | |
| Hamanumida daedalus (Fabricius, 1775) | Nk 6-9 Uledi 7 All areas throughout | G M |
| Neptis alta Overlaet, 1955 | Chis 5 Mkw Kahanga R 9 Lik 12 Nk 5-8 | F M |
| Neptis aurivillii aurivillii Schultz, 1913 | Mug 5&11 | M |
| Neptis carcassoni van Son, 1959 | Kalwe 8 | M |
| Neptis incongrua | Mt Man 4 | M |
| Neptis incongrua | Ntchisi 10 | M |
| Neptis incongrua | Uz 1 | M |
| Neptis incongrua Butler, 1886 | Zomba 5 | M |
| Neptis jordani Neave, 1910 | Chipoka Lun Swamp 4-6&10 | M |
| Neptis kiriakoffi Overlaet, 1955 | Crater 8 Kawia 8 Nk 10 Zaro 2 | M |
| Neptis laeta Overlaet, 1955 | Chambe 5 Crater 8 Lun Swp 6 Nk 6 | M |
| Neptis melicerta Drury, [1772] | Kalwe 5 Lichenya 1 Ruo 3 | G M |
| Neptis sp nova – nina group | Ruo 2,5,9,11 | M |
| Neptis nina Staudinger, 1896 | Mug 4-5, 11-12 | M * |
| Neptis penningtoni van Son, 1977 | Crater 8&11 Kuche 8 Nk 6&9-10 Ruo 9-10 Uledi 7 | M |
| Neptis saclava marpessa Hopffer, 1885 | Km9T 2 Lik 4 Mkw 5 Mpat 7 Nk 5-9 Ruo 10-11 | F G M |
| Neptis serena serena Overlaet, 1955 | Crater 8 Kalwe 8 | M |
| Neptis swynnertoni Trimen, 1912 | Ruo 5,7,9-10 | G M |
| Neptis trigonophora trigonophora Butler, 1878 | Kalwe 4-5&8 | G M |
| Neptis unplaced 1 | Crater 8 Juniper 10 Kalwe 8 Kuche 8 Nk 10 Ruo 9-10 Zaro 2 | M |
| Neptis unplaced 2 | Crater 8 | M |

| Species | Site | Person |
|---|---|---|
| Neptis unplaced 3 | Chagwa 8 Nk 6 Ntchisi 3 | M |
| Neptis unplaced 4 | Chagwa 8 Mpat 7 Mug 6 Nk 6&9-10 | M |
| Neptis unplaced 5 | Chagwa 8 Mpat 7 Nk 8 Ruo 4 | M |
| Neptis unplaced 6 | Lun Swp 6 Uz 4 | M |
| Neptis unplaced 7 | Nk 6 Ntchisi 3 Uz 4 Zaro 2 | M |
| Neptis unplaced 8 | Chambe Plat 5 | M |
| Neptis unplaced 9 | Nk 6 | M |
| Neptis unplaced 10 | Nk 6 | M |
| Neptis unplaced 11 | Uz 4 | M |
| Neptis unplaced 12 | Uledi 7 | M |
| Neptis unplaced 13 | LMNP 5 | M |
| Neptis unplaced 14 | Kalwe 6 | M |
| Neptis unplaced 15 | Crater 8 | M |
| Netpis unplaced 16 | Nk 10 | M |
| Pseudacraea boisduvali trimeni Butler, 1874 | Kalwe 5 Mpat Ruo 12 Thyolo 5-7 9-11 | G M |
| Pseudacraea deludens deludens Neave, 1912 | Ruo 10-11 | M * |
| Pseudacraea deludens murphyi Hecq, 1991 | Matipa 12 Mug 12&4-5 Mt Uzumara 2 | M * |
| Pseudacraea eurytus conradti Oberthur, 1893 | Chis 1 Crater 8 Kalwe 4 Mkw 9 Ruo 4 | G M |
| Pseudacraea lucretia expansa (Butler, 1878) | Chis 1&5 Kalwe 2&5 Nk 5 Ruo 10-11 | G M |
| Pseudacraea poggei (Dewitz, 1879) | | C |
| Pseudargynnis hegemone (Godart, [1819]) | Nk 6 Fringes of evergreen forests | G M |
| Sallya amulia rosa (Hewitson,1877) | Kasungu NP 12 Mul N Bay E Nyika | G M |
| Sallya boisduval boisduval (Wallengren), 1857 | Crater 8-10 Kas 1 Mkw 5 Nganda 4 Nk 6&12 Ruo 9-10 | G M |
| Sallya moranti moranti (Trimen, 1881) | KR 4 Mkw 5 Mug 5&11 Ruo 8-10 | G M |
| Sallya pechueli rhodesiana (Rothschild, 1918) | Livingstonia 3 | G |
| | | |
| | | |
| **Nymphalinae** | | |
| Antanartia dimorphica dimorphica Howarth, 1966 | Kas 12-1 Mt Man 4 Mug 5 Nganda 3 Z 5 | F G M |
| Antanartia shaeneia dubia Howarth, 1966 | Kas 12-1 Mt Man 4 Mug 5-6 Ruo 9-10 Uz 2 Z 5 | G M |
| Catacroptera cloanthe cloanthe (Stoll, [1781]) | Bvumbwe Chelinda J 10 Kuche 6 Mpat 6 Nk 6 T Gate 10 Uz 4 | F G M |
| | Plateau marshy ground 2-4 7-9 | |
| Cynthia cardui (Linnaeus, 1758) | Kajilirwe 6 Kas 1 Nk 6-7 All open habitats | G M |
| Hypolimnas anthedon anthedon Doubleday, 1845 | Chis 5 Crater 5 Kalwe 5 Ruo 4 | M |
| Hypolimnas anthedon whalbergi (Wallengren, 1857) | Mkw Mt Man 4 Uzuzu 4 | F G M |
| Hypolimnas deceptor deceptor (Trimen, 1873) | Maiwale Monkey Bay Mul Thyolo Zomba 5-12 | G |
| Hypolimnas misippus (Linnaeus, 1764) | Limbe 2 Mpat 1 Mkw Nk 1&3 Z 1 | F G M |
| Junonia artaxia Hewitson, 1864 | Sawi 4 Uledi 7 | G M |
| Junonia hierta cebrene Trimen, 1870 | Govati 2 Km3T 1 Mug 6 Z 9 | G M |
| Junonia natalica natalica (Felder & Felder, 1860) | Muchiru 11 Nk 5-6 Ruo 4 Sawi 4 | G M |
| Junonia oenone oenone (Linnaeus, 1758) | Crater 4 Seyama Est, Mul 10 | G M |
| Junonia orithya madagascariensis Guenee, 1865 | Crater 4 Dunduzu 7 J 10 Kas 12-1 Nk 10 Thukutu R 8 | G M |
| Junonia sophia infracta Butler, 1888 | Kalwe 8 Lik Lun swp 5 Mul Ntchisi 5 Thyolo | G M |

| Species | Site | Person |
|---|---|---|
| | swampy areas 11-2 4-6 & 8 | |
| Junonia terea elgiva Hewitson, 1864 | Mug 6 Nk 3 Ruo 9-10 Sawi 4 | G M |
| Junonia touhuilimassa Vuillot, 1892 | CF 7-8 K Gate 1 Km3T 10 Uz 1-2 | M |
| Precis actia (Distsnt, 1880) | Chawezga 8 CF 7 Crater 4 Km3T 3&10 Mpat Ruo 4 Uzuzu 5 | G M |
| Precis antilope (Feisthamel, 1850) | Kazuni 3 Km3T 3&10 Lwnjati 2 Nk 1,5-6&9 Sawi 4 | G M |
| Precis archesia archesia (Cramer, [1779]) | Dedza KR 4 Limbe 4-6&8 Nk 5-6 Ntchisi 5 | F G M |
| Precis ceryne ceryne (Boisduval, 1837) | Lun Swp 6 KR 4 Marshes & Dambos | F G M |
| Precis cuama Hewitson, 1864 | KR 4 Lik 12 Nk 6 Sawi 4 SBFR 3-4 Uzuzu 5 | G M |
| Precis octavia sesamus (Trimen, 1883) | Bt 4 CF 8 J 12 Kas 12-1 Km3T 3&10 Km30C-J 3 Kuche 6 | G M |
| | Limbe 4-6 Nk 5 Nganda 3 Uz 4 All areas | |
| Precis pelarga (Fabricius, 1775) | Record queried – suspect same as actia | C |
| Precis sinuata sinuata (Plotz, 1880) | Kalwe 4-5 | G |
| Precis tugela aurorina Butler, 1894 | CF 7 KR 4 Mt Malawi Mul Nkata Bay E Nyika Ruo 9-10 | G M |
| | Uz 4 Zomba 3-5 9-11 | |
| Salamis anacardii nebulosa Trimen, 1881 | Mt Malawi Monkey Bay Mul Nk 4 Nyika Thyolo 3-5 9-11 | G |
| Salamis cacta amaniensis Vosseler, 1907 | Mt Malawi 2-4 | G |
| Salamis parhassus (Drury, 1782) | Chis 5 Limbe 4 Mt Man 4 Mug 5 Ruo 4 | G M |
| | | |
| **Apaturinae** | | |
| Apaturopsis cleocharis schultzei Schmidt, 1921 | Kuchi 11 Lr Mlunguzi (Wilson) | M * |
| | | |
| **Libytheinae** | | |
| Libythea labdaca laius Trimen, 1879 | Mpat 3 Mt Mal Mul Thyolo Zomba 1-5 9-10 & 12 | G M |
| | | |
| **LYCAENIDAE** | | |
| | | |
| **Lipteninae** | | |
| | | |
| Pentilini | | |
| Alaena amazoula nyasana Hawker-Smith, 1933 | Dz 4 Lik 12 Likoma 3 LiwNP Mpat 4 Muchiru 3 MGR 5 | M Du |
| | Tsenga Mtn 4 Uzuzu 5 | |
| Alaena aurantiaca Butler, 1895 | Mafinga Mtns 4 | M |
| Alaena lamborni Gifford, 1965 | Crater 4 Lik 12 Limbe 12 Mul 2-5 7-12 Z (Collins) | G M * |
| Alaena nyassa nyassa Hewitson, 1877 | KR 4 LMNP 5 Mug 4 Mpat 4-7 Muchiru 5 MGR 4&12 | G M D |
| | Ntchisi 5 Uz 12 Uzuzu | |
| Alaena ochracea Gifford, 1965 | Chikala Mtn 4 Mangochi Mtn 5 Uzuzu 4-5&12 Zomba 9-6 | G M * |
| Alaena picata interrupta Hawker-Smith 1933 | Crater 9 Ruo 5 9 11-2 | M * |
| Alaena reticulata Butler, 1896 | Deep Bay Km30C-J 3 Florence Bay 1&3-4 Mvai Ntcheu 12 | G M |
| Alaena sp | CF 11 Km3T 3 Mondwe 4 Mug 11 | M * |
| Alaena sp | Dz 4 (Sent ABRI) | M * |
| Pentila carcassoni Stempher & Bennett, 1961 | Kalwe 4 Mkw 5 | M * |

| Species | Site | Person |
|---|---|---|
| Pentila pauli nyassana Aurivillius, 1898 | Bvumbwe Crater 4 CSB 3 Kalwe 4&8 KR 4 Lichenya 3 | F M |
| | Lik 12 Limbe 3-4 Ndirande 4 Mkw 4 Nk 3-5 Ruo 10-11,2&5 | |
| | Z 4 | |
| Pentila tropicalis tropicalis (Boisduval, 1847) | LNP Mt Malawi 3 | M D |
| Ornipholidotes peucetia peucetia (Hewitson, 1866) | Crater 4 CSB 4 Kalwe 5 Limbe 4 Mt Malawi Nk 1&4 | M |
| | | |
| Liptenini | | |
| Baliochila hildegarda (Kirby, 1887) | Bt 3-4 Crater 4 Kalwe 4-5 KR 4 Lik 4&12 MNP Nk 12&3-4 | M D |
| | Ntchisi 5 Uzuzu 4-5 Z 4 | |
| Baliochila lipara Stempher & Bennet, 1953 | Chilwa Ruo 4 Mt Man 4 Uzuzu 4 Zomba 4-5 &12-1 | G M |
| Baliochila neavei Stempher & Bennet, 1953 | Bt 3-4 Bvumbwe Crater 4 Lik 4 Limbe 11-12 Luchenza Ruo 3 | F G M |
| | Zomba 9-1 | |
| Baliochila nyasae Stempffer & Bennett, 1953 | Crater 4 Lik 12 TRF 4 | M * |
| Baliochila | woodi (Riley, 1943) Crater 2, 5, 9 Ruo 9-10&2 | M * |
| Baliochila woodi group NYI | Mt Man 4 | Clough |
| Baliochila NYI | Lik 4 | M |
| Baliochila NYI | Ifisa 4 | M |
| Cooksonia aliciae Talbot, 1935 | Uzuzu 11-12 Bampton | * |
| Cooksonia neavei rhodesiae Pinhey, 1962 | Dz11 Nk11 | M |
| Deloneura ochrascens littoralis Talbot, 1935 | Kalwe 7 Mul 3 & 5 | G M |
| Deloneura subfusca Hawker-Smith, 1933 | Mchinje 3 | G |
| Gnodontes vansomeroni Stempffer & Bennett, 1953 | Kazuni 3 LNP Mpat 7-8 | G M D |
| Mimacraea costleyi Druce 1912 | Lichenya 3-4 Limbe 11&3-4 Ruo 10-11 | M * |
| Mimacraea marshalli marshalli Trimen, 1898 | Brachystegia woodland 4-5 & 12 KR 4 Nk 1 | G M |
| Mimacraea skoptoles Druce, 1907 | Mbowe Dam 4 Mzuzu 3 | M |
| Teriomima puella Kirby, 1887 | Chisasira Crater 4 Kalwe 5 Lik 12 | M |
| | | |
| **Lyphyrinae** | | |
| | | |
| Aslauga marshalli Butler, 1899 | Kalwe 4 | M |
| | | |
| **Melitinae** | | |
| | | |
| Lachnocnema bibulus Fabricius, 1793 | CSB 4-5 Km3T 10 Limbe 5 LiwNP Luyangwa Swamp 6 | M Du |
| | Mulanje (Collins) Nk 1,3&11-12 Zaro 2 | |
| Lachnocnema brimo Karsch, 1893 | Chowo 6 CSB 4 Km3T 3 Limbe 5 LiwNP Mug 6&12 | G M Du |
| | Mul 9-10 12-3 Nk 9&12-1 Ntchisi 4&5 Sonjo Hill 2 | |
| Lachnocnema durbani Trimen, 1887 | Bt Limbe MNP 4 Nkhota kota Ntchisi 5 SE Lakeshore Z | G M |
| Spalgis lemolea Druce, 1890 | Bt 4 Kalwe 8 Ndirande 4 Nk 1&4-5 Ruo 10-11 | M |
| | | |
| **Theclinae** | | |

| Species | Site | Person |
|---|---|---|
| | | |
| Aphnaeini | | |
| Aloeides conradsi angoniensis Tite & Dickson, 1973 | Sawi Valley (Sent ABRI) | M |
| Aloedes griseus Riley, 1921 | Km24C-J 9 Juniper 8-10 | M |
| Aloeides molomo handmani Tite & Dixon, 1973 | Ntcheu Km18T 10 Km26T 9-10 Juniper 10 | M C * |
| Aphnaeus (Aphnaeus) erikssoni rex Aurivillius, 1909 | Bt Crater Zomba 9-10 | G |
| Aphnaeus (Aphnaeus) flavescens flavescens Stempher, 1954 | Chinteche Manchewe Mkw 11 1-5 | G * |
| Aphnaeus (Paraphnaeus) hutchinsoni Trimen, 1887 | Monkey Bay 12-1 | G |
| Aphneus marshalli Neave, 1910 | Km3T 10 | M |
| Axiocerces amanga (Westwood, 1881) | Ft Man 4 N Bay Ntchisi Nyambadwe KR 3 Lik 12 LiwNP | H Du M |
| | Mt Mal 3 Muchiru 3 MGR 5 Thukutu River 8 | |
| Axiocerces bamptoni Henning & Henning 1996 | Crater 9-10 Ruo 10-11&2 | H M * |
| Axiocerces coalescens Henning & Henning 1996 | Chisasira 1 Mpat 2 Nk 12 Ntchisi 5 Zaro 2 | H M |
| Axiocerces karinae Henning & Henning, 1996 | Chis 5 Dunduzu 5 Dz 1-2 Mpat 2 N Bay 5 Ntchisi 3 Uledi 7 | Bampton M |
| | Senga Bay 5&12 Vizara 5 ZNNP 3 | |
| Axiocerces nyika Henning & Henning, 1996 | Nyika 10&12 | H * |
| Axiocerces punicea punicea (Grose-Smith, 1889) | Bandawe Chisasira 1 Kalwe 8 Mul (Collins) N Bay Z (Collins) | H M |
| Axiocerces tjoane tjoane (Wallengren, 1857) | Cape Maclear Chikala CF8 Juniper 10 Kas 1 Kavuzi 12 | F H M Du |
| | Kazuni 3 LiwNP Mkw 9 Mtangatanga MGR 5 Nk 2,3,9&12 | |
| | Ntchisi 5 SBFR Uledi 7 | |
| Axiocerces unplaced | Ft Man 4 | M |
| Chloroselas pseudozeritis pseudozeritis (Trimen, 1873) | Monkey Bay 3,7,9,12 | G |
| Cigaritis apelles (Oberthuer, 1878) | Lik 8 N.Bay Rd 4 Mpat 2 | G M |
| Cigaritis ella (Hewitson, [1865]) | Kazuni 3 Monkey Bay 9-5 Sonjo Hill 2 Zaro 2 | G M |
| Cigaritis homeyeri (Dewitz, 1887) | Km24T 9 Ntcheu 5, 9 & 12 Nyamkhowa E Nyika Viphya | F G M |
| | Z (Collins) | |
| Cigaritis mozambica (Bertoloni, 1850) | Chawezga 8 Choma Mtn 1 J 10 Kalindamawe 8 Kalwe 8 | G M |
| | Km9T 2 Mt Mal Mul Plat Mug 5 E Nyika Shire Highlands 8 | |
| | Uz 2 Viphya Plat ZNNP 11 | |
| Cigaritis natalensis (Westwood, [1851-2]) | Dunduzu 12 Mt Mal 3 Mul Nk 1 Nyamkhowa Mt Thyolo | G M |
| Cigaritis nyassae (Butler, 1884) | Chis 1 Kalwe 9 Kazuni 3 Mt Malawi 5 Mul (Collins) | G M |
| | Ndirande 4 Nk 4&12 Thukutu 8 | |
| Cigaritis phanes (Trimen, 1873) | Mpat 1 | G |
| Cigaritis trimeni trimeni (Neave, 1910) | | C |
| Cigaritis victoriae (Butler, 1884) | Manchewe Nyamkhowa 5 & 11 | G |
| Crudaria leroma (Wallengren, 1857) | Chilwa Lik 12 Limbe 11-2 | G M |
| Lipaphnaeus aderna spindasoides (Aurivillius, 1916) | Mu E Nyika Thyolo 8-6 | G |
| Myrina dermaptera nyassae Talbot, 1935 | Dowa Mul Nk 2&10-11 Rukuru River 2 Uzuzu 6-8 | G M |
| Myrina silenus ficedula Trimen, 1879 | Mul (Collins) Nk 8-10&12 | G M |

| Species | Site | Person |
|---|---|---|
| | | |
| | | |
| Deudorigini | | |
| Capys brunneus brunneus Aurivillius, 1916 | KR 4 Mul Plat 1, 5, 7, 12 | G M |
| Capys connexivus connexivus Butler, 1897 | Choma Mt 1 KR 4 Minunu Hut 9 Ntcheu 3 | G M |
| | Shire Highlands Zomba | |
| Capys sp | CF 4 Kaseramba 1 Km8CTO ZNNP 11Km24T 7 Nyamkhowa 2 M | |
| | J 10 | |
| Deudorix (Virachola) antalus (Hopffer, 1855) | Chowo 9 CSB 4 Juniper 10 Kalwe 7 Mpindika 7 Nk 10 LiwNP | M Du |
| | Uledi 7 Uyuzi 12 | |
| Deudorix (Pilodeudorix) caerulea Druce, 1880 | Bt Chim 3 CF 7 Dunduzu 12 Juniper 10 Kazuni 10 Km9T 12 | G M |
| | Mul Nk 10 Nsanje NW lakeshore Uz 12 Zomba | |
| Deudorix (Virachola) caliginosa Lathy, 1903 **To be confirmed** | Nk 10 | M |
| Deudorix (Pilodeudorix) camerona katanga Clench, 1965 | Chiteche Kalwe 6 Manchewe Nk 8 E Nyika 10-11 | G M |
| Deudorix (Virachola) dariaves Hewitson, 1877 | Kalwe 8 L'stonia Mul Zomba 1-5 9 11 | G M |
| Deudorix (Virachola) dinochares Grose-Smith, 1887 | L'stonia Mangochi Mkw 9 Monkey Bay Mpat 9 Mpindika 7 | G M |
| | Ruo 9-10 | |
| Deudorix (Virachola) dinomenes Grose-Smith, 1887 | Crater Nsanje Salima Zomba | G |
| Deudorix (Virachola) diocles Hewitson, 1869 | Bt 4-5 Chambe Mt Chikala 6 Chim 12 Dz 11 Juniper 9-10 | F G M |
| | Kas 12 Lik 4&12 | |
| | Michiru 6 Nk 6&10-11 | |
| Deudorix (Hypokopelates) kafuensis Neave, 1910 | Chawezga 8 K Gate 7 Km3T 3 Km(T 2-3 KR 3 Nk 6 | G M |
| | N. Rukuru 8 L'stonia Sonjo Hill 2 | |
| Deudorix (Virachola) lorisona coffea Jackson, 1966 | Chis 2 Kalwe 7-8 Mangochi Mul Nk 11 E Nyika Uz 2 | G M |
| | Vizara 2-8 & 12 | |
| Deudorix (virachola) magda Gifford, 1966 | Bt Kazuni 3 Nyamkhowa 2 E Nyika 4-5 Ruo 5 | G M |
| Deudorix (Virachola) montana (Kielland, 1985) | Mug 2& 12 Uz 2 | M D |
| Deudorix (Virachola) penningtoni ? van Son 1949 | Km24C-J 11 | M |
| Deudorix (Virachola) vansoni Pennington, 1948 | Bt Nsanje 11-5 | G |
| Deudorix (Pilodeudorix) zeloides (Butler, 1901) | Bt Bua R Chis 5 Chitimba Choma Mt. 1 Km3T 3 L'stonia | G M |
| | Mul Nyika 12-5 ZNNP 3 | |
| Deudorix sp NYI | CSB 5 | M |
| | | |
| Hypolycaeini | | |
| Hypolycaena auricostalis auricostalis (Butler, 1897) | Chim 3&10 CF 8 Dedza Dz 11 J 10 Kalwe 3 Luwawa 11 | G M |
| | Mpindika 8 Nyamkhowa 2-3 7 11 Uz 12 | |
| Hypolycaena buxtoni buxtoni Hewitson, 1874 | CF 8 Km5T 3 Lik 12 Liv'stonia 2 Mpindica 8 Nk 4,6,9-10&12 | M |
| | Ruo 3 Uledi 7 | |
| Hypolycaena caeculus caeculus (Hoppfer, 1855) | Chis Lik 12 Mpat 7 Ntchisi 11-12 | M |

| Species | Site | Person |
|---|---|---|
| Hypolycaena hatita japhusa Riley, 1921 | Kalwe 4-5 Manchewe Falls 2 N Bay Dist 8 & 11-12 Ntchisi 5 | G M |
| Hypolycaena lochmophila Tite, 1967 | Lik 12 Mul Ruo 11 Zomba | C M |
| Hypolycaena pachalia Butler, 1888 | Chambe Manchewe Nyamkhowa 2-5 | F G |
| Hypolycaena philippus philippus (Fabricius, 1793) | Kalwe 3&5 Kazuni 3 LNP Lik 12 LiwNP MNP MGR | G M D Du |
| | Mug 11 Ndirande 5 Nk 1 Ntchisi 5 Rumphi 4 Uyuzi 3 Uzuzu 4 | |
| Leptomyrina (Leptomyrina) hirundo (Wallengren, 1857) | Bt Limbe LiwNP Monkey Bay Mul Nsanje Z (Collins) | G Du |
| Leptomyrina (Gonatomyrina) handmani Gifford, 1965 | Bt Dz 4 Limbe Mt Man 4 Mul Ndirande 4 Nsanje Zomba | G M * |
| | | |
| Iolaini | | |
| Aphniolaus pallene (Wallengren, 1857) | Chinteche Dz 11 Manchewe Monkey Bay Mul Nk 10&12 | G M |
| | Zomba 11-1 | |
| Argiolaus lalos lalos Druce, 1896 | Bt Chinteche Mangochi Mul E Nyika Zomba 12-6 | G |
| Argiolaus ndolae (Stempffer & Bennett, 1958) | Bt 3 & 5 Lukon 11 | G M |
| Argiolaus silarus (Druce, 1885) | Choma Mtn 1 Mul E Nk 11-12 Nyika Shire Highlands | G M |
| | Zomba 2-6 9-12 | |
| Argiolaus pamae Heath, 1994 | Mafinga Mtns | C |
| Epamera aemulus (Trimen, 1895) | Uyuzi 12 | M |
| Epamera alienus alienus (Trimen, 1898) | Bt Km3T 10 Mul 11-12 | G M |
| Epamera bakeri Riley, 1928 | Bt Mul 12-5 | G |
| Epamera handmani Gifford, 1965 | Mitsidi Hill, Bt 12 | G * |
| Epamera helenae Henning & Henning, 1989 | Chowo Mt Uzumara 1-2 | M * |
| Epamera mimosae rhodosense (Stempher & Bennett, 1959) | Bt Monkey Bay 5-7 & 12 | G |
| Epamera sidus (Trimen, 1864) | Bt Mul Nk 12 Ntchisi 5 E Nyika | G M |
| Epamera silanus alticola ( Stempffer, 1961) | Mug 11 Willindi 12 | M |
| Epamera nasisii Riley, 1928 | Ifisa Hill 2 Sonjo Hill 2 | M |
| Epamera violacea Riley, 1928 | Bt Lik 12 Nganda 3 Zomba 1, 2, 5 | G M |
| Iolaphilus trimeni (Wallengren, 1875) | Bt Mul Ntchisi 5 ZNNP 12 Zomba 2-7 & 11 | G M |
| Philiolaus stewarti Heath, 1985 | Juniper 9 Mafinga Mtns Mug 6&12 Zomba(Collins) | M |
| Stugeta bowkeri nyasana (Talbot, 1935) | Lik 12 Manchewe Mpat 3-4 Shire Valley 2-9 Uzuzu 11 | G M |
| | | |
| **Lycaeninae** | | |
| Lycaena phlaeas abbotti (Holland, 1892) | Juniper 10-11&3 Kas 12-1 Km30C-J 3 Maiwale | G M |
| | Zomba Plat 3-5 9-10 Willindi 12 | |
| **Polymatinae** | | |
| | | |
| Lycaenesthini | | |
| Anthene amarah amarah (Guerin-Meneville, 1849) | CSB 3-4 Kazuni 3 Limbe 4 Muchiru 3 Ndirande 5 | G M |
| | Deciduous woodland 10-5 & 8 | |
| Anthene butleri livida (Trimen, 1881) | Zomba 9 | G |
| Anthene chirinda (Bethune-Baker, 1910) | Mulunguzi 3 | G |
| Anthene crawshayi crawshayi (Butler, 1899) | Bt Monkey Bay L'stonia Mul 4-5 7-10 | G |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| Species | Site | Person |
|---|---|---|
| Anthene definita definita (Butler, 1899) | Juniper 3&8 Km9T 12 Lik 12 Mug 6 Ntchisi 5 | G M |
| | Deciduous formations of high rainfall | |
| Anthene hobleyi Neave, 1904 | Km3CTO 3 Nyamkhowa 2-5 Mug 5&11-12 Uz 12 | G M |
| Anthene kersteni (Gerstaecker, 1871) | Chis 5 Mpindika 7-8 Ntchisi 5 Ruo 5 Uledi 7 | G M |
| | Near water in most formations | |
| Anthene lasti (Grose-Smith & Kirby, 1894) | Bandawe Chis 5 Juniper 8 Kalwe 8 Lik 12 Limbe L'stonia | G M |
| | Manchewe Nk 1 Nyam 2, 4-5, 7, 10-12 Ruo 9-11 | |
| Anthene lemnos lemnos (Hewitson, 1878) | Manchewe Zomba 11 | G |
| Anthene ligures (Hewitson, 1874) | Bandawe Mul E Nyika Thyolo Zomba 1, 4-5 | G |
| Anthene liodes (Hewitson, 1874) | Bt L'stonia Mangochi Monkey Bay Nyamkhowa 2,4 5-7, 9 | G |
| Anthene lunulata (Trimen, 1894) | Mt Choma 1 Kahanga River 9 Km3T 3 Km9T 12 Lik 12 | G M |
| | Luwawa 11 Mpat 2 Mt Man 4 Nk 12 Ruo 2 | |
| Anthene nigropunctata (Bethune-Baker, 1910) | Bt Namweras Rd 1-2 & 4 | G |
| Anthene otacilia otacilia (Trimen, 1868) | Monkey Bay 6-8 | G |
| Anthene princeps princeps (Butler, 1876) | LiwNP Mangoche Monkey Bay Mul (Collins) Zomba 5-7 & 12 | G Du |
| Anthene rubricinctus anadema (Druce, 1905) | E Nyika 1-2, 9, 12 | G |
| Anthene sp | Mt Man 4 | M |
| Anthene sp | L'stonia 2 Mug 11 | M |
| Anthene sp | Juniper 8 Mpindika 8 | M |
| Anthene sylvanus sub sp | Mug 11-12&4-6 | M |
| Triclema nigeriae (Aurivillius, 1905) | Km3T 3 Mpidika 7 Nyamkhowa 1-2, 4, 9 | G M |
| | | |
| Polyommatini | | |
| Actizera lucida (Trimen, 1883) | Chambe 5 J 8&10 Km9T2 Luwawa 11 Ndirande 5 Uzuzu 4 | G M |
| | Deciduous woodland & gardens | |
| Actizera stellata (Trimen, 1883) | Chikala 2 Chilinda 12 J 10 Kas 1 Km30C-J 3 Nganda 3 | F G M |
| | Viphya montane grassland 3, 8, 9 | |
| Azanusjesous jesous (Guerin-Meneville, 1849) | Florence Bay Kazuni 3 Mangochi Monkey Bay Mpat 11 Ruo G M | |
| | Zomba | |
| Azanus mirza (Plotz, 1880) | Limbe Monkey Bay Mul E Nyika Thyolo Uz 2 Zomba 3-12 | G M |
| Azanus moriqua (Wallengren, 1857) | Bua Chilwa Lik 12 Limbe Monkey Bay E Nyika | G M |
| | Zomba 1,3,5,8-12 | |
| Azanus natalensis Trimen, 1887 | Chiromo CSB 4-5 Limbe Manchewe Mpindika 7-8 Mul | G M |
| | Nyamkhowa | |
| | Thyolo 1-4 6-7 11-12 Uledi 7 | |
| Azanus ubaldus (Stoll, [1782]) | Monkey Bay 8-12 | G |
| Cacyreus lingeus (Stoll, [1782]) | Chilinda CF 8 Ft Lister 6 Kazuni 3 Km30C-J 3 Limbe 4-5 | F G M |
| | Mbowe Dam 4 Mt Man 4 Mug 6 Ndirande 5 Nganda 5 Nk 9 | |
| | Ntchisi 5 Z (Collins) | |

| Species | Site | Person |
|---|---|---|
| Cacyreus palemon palemon (Stoll, [1782]) | Chambe 5 Chilindaa J 3&10 Kas 1 Km3CTO 3 Km30C-J 3 | F G M |
| | Minunu Hut 6 Mug 5-6 Nganda 3 Nyamkhowa Uz 4 Zomba | |
| | near streams | |
| Cacyreus virilis Stempffer, 1936 | Chinteche Chowo 9 J 3 Km30C-J 3 Limbe 3 Mpat Ntchisi 5 | G M |
| | Nsanje Tsenga 4 Uzuzu 4 Zomba | |
| Cupidopsis cissus (Godart, [1824]) | CSB 4 Dz 11 J 10 Kalindamawe 8 Kaseramba 1 Km 24T 9-10 | G M |
| | Lik 12 Mug 8 Ntchisi 3 Uz 2 Z (Collins) | |
| Cupidopsis jobates jobates (Hopffer, 1855) | Limbe Florence Bay Mul N Bay Nyamkhowa Thyolo 11-5 | G |
| Eicochrysops hippocrates (Fabricius, 1793) | Kalwe 3-4 Lik 12 Mug 5-6 | G M |
| | N Bay closed forests Shire Highlands | |
| Eicochrtsops messapus Mehallokoaena (Wallengren, 1857) | J 7&9 Km3T 3 Km9T 2 Ntchisi 5 | G M |
| | Drier deciduous woodland and high grasslands 1-4, 9, 11 | |
| | Mt Dedza Peak 11 | |
| Euchrysops barkeri (Trimen, 1893) | Bt Limbe Florence Bay Monkey Bay E Nyika Ft Lister 6 | G M |
| | Mpindika 7 Mt Tsenga 3 Zomba 1,6-7,9-10 | |
| Euchrysops malathana (Boisduval, 1833) | Ft Man 4 Mt Choma 1 Dz 1&4 J 10 Ft Lister 6 Kahang River 9 G M | |
| | Kas 1 LMNP 11 Lik 12 Limbe 4-5 Ndirande 4-5 Nk 1 Ntchisi 5 | |
| | T Gate 9 Mt Tsenga 4 Ruo 2 Uledi 7 Z (Collins) | |
| Euchrysops osiris osiris (Hopffer, 1855) | Bt Crater 4 Kahanga River 9 Lik 12 Limbe 5 L'stonia 5-7 | G M |
| | Tsenga Mt 4 Mul plat MGR 5 Uzuzu 4 | |
| Euchrysops subpallida Bethune-Baker, 1923 | Choma 1 J 8&10 KR 11 Km9T 12 Lik 12 Limbe Luchenza | G M |
| | Luwawa 11 Mpindika 7-8 Mug 12 Sonjo Hill 2 T Gate 9Thyolo | |
| | Viphya plat 1-3,5,8-12 | |
| Eucrysops unigemmata (Butler, 1895) | CF 1 J 7&10 Km24T 10 Mpindika 7-8 | M * |
| Freyeria trochylus (Freyer, [1843]) | Mul (Collins) Z (Collins) | G |
| | Low vegetation – Deciduous plat & scarp | |
| Harpendyreus hazelae Stempffer, 1973 | Kas 1 Km30C-J 3 Mug 12 Mt Uzumara 2-3 | M * |
| Harpendyreus juno (Butler, 1897) | J 3 Km30C-J 3 Nganda 3 Viphya Plat near streams 3 & 7 | F G M |
| Lampides boeticus (Linnaeus, 1767) | CF 8 J 8-10 Kas 12-1 Km3T 10 Km30C-J 3 Limbe 4-5&8 | F G M |
| | Mug 6 Mul (Collins) Nk 6 Ntchisi 5 VMGR 10 Z (Collins) | |
| Lepidochrysops aethiopica (Bethune-Baker, 1923) | Chilwa Limbe Mpat 2 Mul Zomba 11-2 | G M |
| Lepidochrysops auratus Quickelberge, 1979 | Namizimu forest | C * |
| Lepidochrysops chalceus Quickelberge, 1979 | CTO 10 Hill nr Chowo 10 J 10-11 Km8CTO ZNNP 10 | M * |
| Lepidochrysops chloauges (Bethune-Baker, 1923) | Fulevera forest at Deep Bay 2-4 KR 11-12 Ntchisi 11 | G M |
| Lepidochrysops cupreus Neave, 1910 (**Incorrect ID – see chalceus**) | Nyika 11-12 | G |
| Lepidochrysops delicata (Bethune-Baker, 1923) | Lik 11-12 Zomba 11-2 | G M |

| Species | Site | Person |
|---|---|---|
| Lepidochrysops desmondi Stempffer, 1951 | Dz 11 Ifisa 4 Km3T 3 Km5T 10 Km8CTO ZNNP 11 | G M |
| | Uzuzu 12 | |
| | Manchewe | |
| Lepidochrysops dolmani Bethune-Baker, 1923 | KR 12 | C M |
| Lepidochrysops gigantea (Trimen, 1898) | Chinteche Dz 11 Karonga KR 11 Lilongwe Mul 11-1 & 3 | G M |
| | Uzuzu 11-12 | |
| Lepidochrysops glauca glauca (Trimen, 1887) | Chikwawa Malawe Hills 11 & 3 | G |
| Lepidochrysops handmanni Quickelberge, 1980 | Chosi 10 Hill nr Chowo 10 J 10 Kaulime 9 Km24C-J 11 | M |
| Lepidochrysops intermedia intermedia (Bethune-Baker, 1923) | Lik 12 Mvai Mtn-Ntcheu Ruo Zomba 12-2 | G M |
| Lepidochrysops intermedia cottrelli Stempffer, 1954 | J 10 Nyika 11 | G M * |
| Lepidochrysops longifalces Tite, 1961 | Mirale Station (Railway) Mitsidi Hill 1-2 | G |
| Lepidochrysops neavei (Bethune-Baker, 1923) | L.Chilwa Limbe Mul Zomba 11-1 | G |
| Lepidochrysops neavei nolani Williams, 2002 | Uzuzu Hill 12-1 | Owen-Joh |
| Lepidochrysops nyika Tite, 1961 | J 10-11 W Nyika 9 | G M * |
| Lepidochrysops parsimon parsimon (Fabricius, 1771) | Manchewe | G |
| Lepidochrysops patricia (Trimen, 1887) (Doubtful record) | Deciduous woodland on rocky hills | C |
| Lepidochrysops peculiaris hypoleucus (Butler, 1894) | Mitsidi Hill 11-1 | G |
| Lepidochrysops plebia plebia (Butler, 1898) | Chilwa Zomba 1 & 3 | G |
| Lepidochrysops pompolis Druce, 1905 | KR 12 | M |
| Lepidochrysops solwezii (Bethune-Baker, 1923) | KR 12 Matambwe Hill-Deep Bay Ntcheu 1 Uzuzu 12 | G M |
| Lepidochrysops violetta (Pinhey, 1945) | Nyika | C |
| Lepidochrysops sp nova | Chim 11 Dz 11 | M |
| Lepidochrysops sp | Tsenga 3-4 | M |
| Lepidochrysops sp | Ngara 12 | M |
| Lepidochrysops sp | Ngara 12 | M |
| Leptotes babaulti (Stempffer,1935) | Bt Likoma Luchenza N Bay Zomba | G M |
| Leptotes brevidentatus (Tite, 1958) | Luchenza | G M |
| Leptotes jeanneli (Stempffer, 1935) | Limbe Luchenza Monkey Bay Zomba | G M |
| Leptotes pirithous pirithous (Linnaeus, 1767) | Bvumbwe | C F M |
| Leptotes pulchra (Murray, 1874) | | C |
| Oboronia bueronica Karsch, 1895 | Chis Kalwe Mkw 4&12 | G M |
| Phylaria hiritsia virgo (Butler, 1896) | Chinteche Lunyangwa Swamp 5 Nk 1 E Nyika Mug 5 | G M |
| | Viphya Plat 2-7 | |
| Pseudonacaduba sichela sichela (Wallengren, 1857) | Lik 12 LiwNP Mpindika 7-8 Mt Man 4 Ntchisi 5 | G M Du |
| | Near water at all elevations | |
| Tarucus sybaris sybaris (Hopffer, 1855) | Limbe Muchiru 3 Monkey Bay 8 12-2 | G M |
| Thermoniphas micylus colorata (Ungemach,1932) | Kalwe 5&7-8 Mul N Bay forests 2, 5, 8 | G M |
| Tuxentius calice calice (Hopffer, 1855) | CSB 4 Nk 6 Muchiru 3 Mul (Collins) Uledi 7 Z (Collins) | G M |
| | Low alt closed forests | |
| Tuxentius ertli (Aurivillius, 1907) | Chikangawa 3 K Gate 7 Limbe Myamkhowa Mug 12&4-5 | G M |
| | Thyolo Mtn Uz 12-2 throughout z (Collins) | |

| Species | Site | Person |
|---|---|---|
| Tuxentius melaena melaena (Trimen, 1887) | LiwNP Luchenza Mt Mal Mul Zomba plat 5-8 & 10 | G Du |
| Uranothauma antinorii felthami (Stevenson, 1934) | Mul Mug 5-6 E Nyika Shire Highlands | G M |
| Uranothauma confusa Kieland, 1989 | Mulanje (Collins) Zomba | Kieland |
| Uranothauma crawwshayi Butler, 1895 | Juniper 12 Kaseramba 12-1 Nyamkhowa 12 Mul | G M |
| Uranothauma cuneatum Tite, 1958 | Kas 12 Km30C-J 1 Nyamkhowa 9 | G M |
| Uranothauma falkensteini (Dewitz, 1879) | Limbe L'stonia Mt Man 4 Mug 12 Ntchisi 5 Nyamkhowa | G M |
| | Ruo 9-10 Viphya Zomba 2,5,7,9-12 | |
| Uranothauma nubifer (Trimen, 1895) | Bt CF 8 Dedza Limbe Mt MaN 4 Mug 12 Ntchisi 12 | G M |
| | Nyamkhowa Ruo 9-11 Uledi 7 Zomba 1-7 9-11 | |
| Uranothauma pocggei (Dewitz, 1879) | Bt Chinteche Dedza Lik 12 Limbe Mt Man 4 Mug 5-6 Lik 12 | G M |
| | E Nyika Sonjo Hill 2 Zomba | |
| Uranothauma vansomereni Stempffer, 1951 | Limbe Monkey Bay? E Nyika Zomba | G |
| Uranothauma williamsi Carcasson, 1961 | Handman | |
| Zintha hintza hintza (Trimen, 1864) | Limbe N Province 4, 9 | G |
| Zizeeria knysna (Trimen, 1862) | Kazuni 3 Limbe 5 LiwNP Man Swamp 5 Mug 6 MGR | G M D |
| | Ndirande 4 Tsenga Mt 4 Z (Collins) | |
| Zizina antanossa (Mabille, 1877) | Mul 9 | G |
| Zizula hylax (Fabricius, 1775) | CF 8 Lik 12 Limbe 5 LiwNP Man Swamp 5 MGR Mpindika 8 G M Du | |
| | Mug 6 Ndirande 5 Ntchisi 5 Z (Collins) | |
| **RIODINIDAE** | | |
| | | |
| **Hamaerinae** | | |
| Abisara delicata delicata Lathy, 1901 | Mt Chikala Kaninyinga 11 Likhubula 12 Luchenza Mimosa 4 | G M |
| | Zomba | |
| Abisara neavei congdoni Kielland, 1985 | Mpindika River – Nyika 8 | M |

# E: GPS records of all sites

The table below shows the GPS records for all sites listed in Appendix 3D (updated in February 2015).

| Site | Abbreviation |
|---|---|
| Acacia Grove, Rumphi Dist. Nyika Nat. Pk. N. Malawi 2070m 10° 37´S 34° 40´E | Ac Gr |
| Bangula Hill Nsanje Dist. S.Malawi 90m 16° 36´S 35° 05´E | Bangula Hill |
| Barra Village S end Lake Malawi Mangochi Dist. S Malawi 477m 14° 24.9´S 35° 15´E | Barra |
| Blantyre. S.Malawi. 1050m. 15° 46´S 35° 00´E | Bt |
| Bleak Ridge off Km 29 Chelinda- Juniper Rd Nyika Nat. Pk. N.Malawi 2460m 10° 41.3´S 33° 57.3´E | Ridge |
| Bua River Lodge Nkhota kota Dist C.Malawi 580m 12° 50.1´S 34° 05.1´E | Bua |
| Bungulo forest Nkata Bay Dist N. Malawi 920m 11° 39´S 34° 17´E | Bungulo |
| Bunda. Lilongwe Dist. C.Malawi. 1300m 14° 11´S 33° 46´E | Bunda |
| Bunganya Forest Reserve Mzimba zdist. N.Malawi 1775m 11° 19´S 33° 46´E | Buganya FR |
| Bvumbwe. Thyolo Dist. S.Malawi. 1000m 15° 56´S 35° 03´E | Bvumbwe |
| Chagwa River, Malosa Mtn, Machinga Dist. S.Malawi 1000m 15° 14.7´S 35´ 17´E | Chagwa R |
| Chambe Plateau. Mt Mulanje. S.Malawi. 1900m 15° 55´S 35° 32´E | Chambe Plat |
| Champoyo | |
| Chikala Forest Reserve Machinga Dist. S.Malawi 700m 15° 09´S 35° 23´E | Chikala FR |
| Chikala Hills Machinga Dist. S.Malawi 1000m 15° 08´S 35° 21´E | Chikala Hills |
| Chikala Mtn Machinga Dist. S. Malawi 1625m 15° 07.5´S 35° 30´E | Mt Chikala |
| Chikangawa. Hill Mzimba Dist. N.Malawi. 1906m 11° 50´S 33° 48´E | Chikangawa |
| Chikonje | |
| Chikwawa. S.Malawi. 130m. 16° 01´S 34° 46´E | Chikwawa |
| Chilinda Bridge. Nyika Nat. Pk. N.Malawi. 2240m 10° 40´S 35° 51´E | Chilinda Br |
| Chilinda Camp Nyika Nat. Pk. Rumphi Dist. N.Malawi 2310m 10° 35´S 33° 49´E | Chilinda |
| Chimaliro Forest Reserve. Kasungu Dist. C.Malawi. 1310m. 12° 27.7´S 33° 32.4´E | Chim |
| Chingwi's Hole. Mt Zomba Plateau. S.Malawi. 1910m. 15° 18.5´ S 35° 16´E | Chinwi's Hole |
| Chinteche. Nkhata Bay Dist. N.Malawi. 500m 11° 50´S 34° 10´E | Chinteche |
| Chinzama – Tuchila Hut Mt Mulanje S. Malawi 2340m 15° 54´S 35° 38´E | |
| Chiosia Hill Lilongwe Dist. C.Malawi 1400m 13° 39.5´S 33° 34´E | Chipande |
| Chopka –Lakeshore 1km S of- C Malawi 475m 14° 08´S 34° 31.2´E | Chipoka |
| Chipome River Chitipa Dist. Nyika Nat. Pk. N.Malawi 1430m 10° 19´S 33° 49´E | Chipome R |
| Chiromo. Nsanje Dist. S.Malawi. 300m 16° 32´S 35° 09´E | Chiromo |
| Chisanga Falls Nyika Nat. Pk. Chitipa Dist. N.Malawi 1850m 10° 32´S 33° 41´E | CF |
| Chisanga Falls Bridge Nyika N.P. N.Malawi 1880m 10° 32.2´S 33° 41.4´E | CF Br |
| Chisara Village. Nkhata Bay Dist. N.Malawi. 600m. 11° 33´S 34° 08´E | Chisara |
| Chisasira Forest Reserve. Nkhata Bay Dist. N.Malawi. 540m. 11° 55.7´S 34° 05.1´E | Chis |
| Chisongeli Forest Reserve. Mt Mulanje. S.Malawi 1625m 16° 05´S 35° 44´E | Chisongeli |
| Chitimba Bay W Lakeshore N. Malawi 10° 32´S 34° 11°E | |
| Chitinje Camp Site Mt Zomba S Malawi 1910m 15° 19.5´S 35° 17´E | Z Plat |
| Chitipa = Fort Hill Chitipa Dist N. Malawi 1300m 9° 43´S 33° 05´E | Chitipa |
| Chiweta Escarpment. Rumphi Dist. N.Malawi. 670m. 10° 42´S 34° 11´E | Chiweta Esc |
| Chiwezga School. 10 Km from Kaperikezi Gate. Nyika Nat. Pk. N.Malawi 1530m 9° 57´S 33° 41´E | Chiwezga |
| Choma Mountain. Nkhata Bay Dist. N.Malawi. 1840m 11° 17´S 34° 04´E | Choma |

| Site | Abbreviation |
|---|---|
| Chongoni. Resarch Stn. Dedza Dist. C.Malawi. 1300m 14 °12´S 34° 10´E | Chongoni |
| Chosi View Point Nyika Nat Pk. N.Malawi 2380m 10° 36.7S 33° 45,4´E | Chosi VP |
| Chowe Village. Namwera Rd. Mangochi Dist. 950m. 14° 28´S 35° 25´E | Chowe |
| Chowo Forest. Zambia Nyika Nat. Pk. 2175m. 10 °35.6´S 33° 41.5´E | Chowo |
| Chungu River Misuku Hills.. Chitipa Dist. N.Malawi 1110m. 9° 45´S 33° 39´E. | Chungu R |
| Club Makakola Salima Dist. C.Malawi. 475m. 14° 17´S 35° 07´E | |
| Crater. Mulanje Mountain. S.Malawi. 1000m 16° 01´S 35° 32´E | Crater |
| Dedza Mountain Peak. Dedza Dist. C.Malawi. 2190m 14° 21´S 34° 20´E | Dedza Pk |
| Dedza Mtn. Lower forest Dedza Dist C. Malawi 1730m 14° 21.7´S 34° 19´E | Dedza F |
| Denbow Bridge Nyika N.P. N.Malawi 10° 32´S 33° 51.3´E | Denbow Br |
| Dunduzu. Nr. Mzuzu. N.Malawi. 1250m. 11° 20´S 33° 54´E | Duduzu |
| Dwambazi Forest Res. Nkhota Kota Dist. C. Malawi 1100m 12° 29.5´S 33° 51.8´E | Dwambazi No1 |
| Dzalanyama Forest Lodge Lilongwe Dist. C Malawi 1230m 14° 15.3´S 33° 26.6´E | Dz FL |
| Dzalanyama Forest Reserve. Lilongwe Dist. C.Malawi. 1300m. 14° 15´S 33° 25´E | Dz |
| Elephant Rock. Viphya Mtns. Nr Chikangawa. N.Malawi. 1700m 11° 43´S 33° 47´E | ER |
| Embangweni Rd. Mzimba Dist. N.Malawi 1400m 12° 02.5´S 33° 30´E | |
| Felimu Village Mpatamanga Rd Neno Dist. S.Malawi 365m 15° 41´S 34° 39.5´E | Felimu V |
| Florence Bay - now Chitimba Bay - see above | |
| Fort Hill - see Chitipa | |
| Fort Johnson. (Mangochi) Mangochi Dist. S. Malawi 1350m. 14° 27´S 35° 30´E | Mangochi |
| Fort Lister. Mulanje Mtn. Phalombe Dist. S.Malawi. 1100m 15° 50´S 35° 42´E | Ft Lister |
| Fort Mangochi Mangochi Dist S Malawi 1368m 14° 26.7´S 35° 28.9´E | Ft Man |
| Fulvera forest Deep Bay Karonga Dist N. Malawi 600m 10° 23´S 34° 15´E | Fulvera F |
| Fwambo | |
| Govati Balaka Dist. S. Malawi 550m 15° 15°S 34° 52´E | Gov |
| Hill Nr Chowo forest Nika N.P. N.Malawi 2170m 10° 42´S 33° 41´E | |
| Hill Juniper forest to Chilinda Bridge Rd. Nyika Nat. Pk. N. Malawi 2290m 10° 45.6´S 33° 52´E | Hill J-CB |
| Ifisa Hill Chawanga Rd. Chitipa Dist. N.Malawi 1550m 9° 30´S 33° 04´E | Ifisa |
| Jembya Forest Reserve. Chitipa Dist. N.Malawi. 1930m. 10° 06´S 33° 25´E | Jembya |
| Juniper Forest. Nyika Nat Pk. N.Malawi. 2215m. 10° 45´S 33° 54´E | J |
| Kabuma River Mzimba Dist. N.Malawi 1200m 11° 21.8´S 33° 46´E | Kabuma R |
| Kahanga River Mtwalo HQ Mzimba Dist. N.Malawi 1250m 11° 21´S 33° 45´E | Kahanga R |
| Kajilirwe River Nkhata Bay Dist. N.Malawi 700m 11° 37.5´S 34° 01.5´E | Kajilirwe R |
| Kalindamawi Camp Vwaza Marsh Game Res. Rumphi Dist. N.Malawi 1215m 10° 59´E 33° 19´E | Kalindamawe |
| Kalwe Forest Reserve. Nkhata Bay Dist. N.Malawi. 600m. 11° 36´S 34° 15´E | Kalwe |
| Kande Swamp Nkhata Bay Dist. N.Malawi 475m 11° 58´S 34° 07´E | Kande |
| Kaninyinga Forest Reserve. Nr Mzuzu. N.Malawi. 1350m. 11° 24´S 34° 05´E | Kaninyinga |
| Kapanji Kajosi Chitipa Dist. Nyika Nat. Pk. N. Malawi 2215m 10° 27´S 33° 45´E | KK |
| Kaperekezi Gate. Nyika Nat. Pk. Chitipa Dist. N.Malawi 1580m 10° 32´S 33° 40´E | K Gate |
| Kapesa Village Nkhata Bay Dist. N.Malawi 500m 11° 54´S 34° 09´E | Kapesa |
| Karonga. N.Malawi. 500m 9° 56´S 33° 56´E | Karonga |
| Karonga North Forest at Mweniwisi. N.Malawi. 720m. 9° 46´S 33° 48´E | Mwen |
| Kasangazi nr. Bandawi Nkhata Bay Dist. N. Malawi 500m 11° 53´S 34° 08´E | Kasangazi |
| Kasaramba Forest. Nyika Nat. Pk. Rumphi Dist. N.Malawi. 2365m 10° 45´S 33° 59´E | Kas |

| Site | Abbreviation |
|---|---|
| Kasengwa River Bridge Mpompa Rd Rumphi Dist. N.Malawi 1200m 11° 00.2´S 34°E | Kas R |
| Kasimba River Karonga Dist. N.Malawi 480m 10° 8.2´S 34°E | Kasimba R |
| Kasitu Lodge Chikangawa Mzimba Dist N.Malawi 1740m 11° 53´S 33° 47.6´E | |
| Kasitu Rock. Dzalanyama Range. Lilongwe Dist. C.Malawi 1620m 14° 28.7´S 33° 37.5´E | KR |
| Kasungu Nat Pk. Lufipa Lodge Kasungu Dist. C.Malawi. 1050m. 13° 05´S 33° 08.3´E | KasNP |
| Kasungu Nat Pk. Gate Kasungu Dist. C Malawi 1050m 13° 7.2´S 33° 15´E | |
| Katumbi forest Rumphi Dist. Nyika Nat. Pk. N. Malawi 1970m 10° 40.7´S 33° 37´E | Katumbi |
| Kawiya Camp Vwaza Marsh Game Res. Rumphi Dist. N.Malawi 1240m 10° 52.7´S 33° 30.7´E | Kawiya |
| Kuche Stream. Mt Zomba. S.Malawi. 1195m. 15° 19.3´S 35° 15.9´E | Kuche |
| Kayilizi Chitipa Dist. N.Malawi 1550m 10° 3.5´S 33° 26.5´E | Kayilizi |
| Kazuni Camp Vwaza Marsh Game Res. Mzimba Dist. N.Malawi 1080m 11° 08´S 33° 38´E | Kazuni |
| Km 3 from Chilinda Turn Off. Nyika Nat Pk. N.Malawi. 2215m. 10° 35´S 33° 43´E | Km3CTO |
| Km 3 from Thazima Gate. Nyika Nat Pk. N.Malawi. 1660m. 10° 48´S 33° 35´E | Km3T |
| Km 5 from Thazima Gate (Boundary Rd.) Rumphi Dist. Nyika Nat. Pk. N.Malawi 1650m 10° 46´S 33° 32´E | Km5T |
| Km 8 Chelinda Turn Off – Kaperikezi Gate Zambia Nyika N.P. 2200m 10° 34´S 33° 40´E | Km8CTO ZNNP |
| Km 9 from Thazima Gate. Nyika Nat Pk. N.Malawi. 1700m. 10° 45´S 33° 39´E | Km9T |
| Km14 from Thazima Gate Nyika Nat. Pk. N.Malawi 1780m 10° 44.2´S 33° 39´E | Km14T |
| Km 17 from Thazima Gate Nyika Nat. Pk. N. Malawi 1920m 10° 43.7´S 33° 39E | Km17T |
| Km 18 from Thazima Gate. Nyika Nat Pk. N.Malawi. 1940m. 10° 43.6´S 33° 39.2´E | Km18T |
| Km18 from Thazima Gate to Chosi Rd. Nyika Nat. Pk. N. Malawi 1950m 10° 43´S 33° 43´E | Km18T-Chosi |
| Km 19 from Thazima Gate Nyika Nat. Pk. N. Malawi 1940m 10° 43.5´S 33° 39´E | Km19T |
| Km 20 Karonga-Chitipa Rd. (Nr N. Rukuru River Br.) Karonga Dist. N.Malawi. 600m. 9° 51´S 33° 45´E | Km20K-C |
| Km 24 Chelinda-Juniper Rd Nyika Nat. Pk. N.Malawi 2440m 10° 41.1´S 33° 54.2´E | Km24C-J |
| Km 24 Thazima Gate Rumphi Dist Nyika Nat. Pk. N.Malawi. 1970m 10° 42´S 33° 37´ | Km24T |
| Km 28 Karonga-Chitipa Rd. Karonga Dist. N.Malawi 800m 9° 54´S 33° 42´E | Km28K-C |
| Km 30 Chelinda – Juniper (Bad) rd. Nyika Nat. Pk. N. Malawi. 2440m 10° 42.03´S 33° 57.24´E | Km30C-J |
| KR - see Mushitu forest Dzalanyama Range | KR |
| Kuche Stream Mt Zomba S.Malawi 1200m 15° 20´S 35° 15´E | Kuche |
| Lake Chilwa Machinga Dist. S. Malawi | |
| Lake Chilwa Zomba Dist. S. Malawi 630m 15° 30´S 35° 40´E | L Chilwa |
| Lake Kaulime Rumphi Dist. Nyika Nat. Pk. N. Malawi 2365m 10° 34.5´S 33° 45.5´E | Kaulime |
| Lake Malawi National Pk. (Hills) Mangochi Dist. C. Malawi 540m 14° 03.4´S 34° 52.5´E | LMNP |
| Lake Malawi Nat. Pk. (Lake) Mangochi Dist. C.Malawi. 480m. 14° 02´S 34° 49´E | LMNP |
| Lake View Point. Chikwawa Rd. Mzimba Dist. N.Malawi. 1500m. 11° 32´S 33° 40´E | LVP |
| Lichenya Forest Res. Mulanje Dist. S.Malawi 550m 16° 07´S 35° 28´E | Lich |
| Lichenya Plateau. Mt Mulanje. S.Malawi. 1800m. 15° 58´S 35° 33´E | Lich Plat |
| Likhubula Forest Reserve. Mt. Mulanje. S.Malawi. 840m. 15° 56´S 35° 30´E | Lik |
| Likulezi Hill. Phalombe Dist. S.Malawi. 780m. 15° 50´S 35° 36´E | Likulezi Hill |
| Lilongwe City C Malawi 1070m 14°S 33° 46´E | LLW |
| Lingadzi. Nr. Lilongwe. C.Malawi. 1100m. 13° 58´S 33° 46´E | Lingadzi |
| Linthipe Lilongwe Dist. C Malawi 1200m 14° 10´S 34° 07.5´E | Linthipe |
| Limbe. Blantyre Dist. S.Malawi. 1160m. 14° 49´S 35° 04´E | Limbe |
| Lisungwe Village Rd. Nr Zelewa. Mwanza Dist. S.Malawi. 450m. 15° 26´S 34° 50´E | Lisungwe |
| Livingstonia. Rumphi Dist. N.Malawi. 1680m. 10° 33.5´S 34° 05´E | L'stonia |

| Site | Abbreviation |
|---|---|
| Liwonde Forest Reserve. Machinga Dist. S.Malawi. 680m. 15° 10´S 35° 18´E | LiwFR |
| Liwonde Nat. Pk. Machinga Dist. S.Malawi. 500m. 15° 01´S 35° 15´E | LiwNP |
| Lower Chilinda Bridge Nyika N.P. N.Malawi 1820m 10° 45.3´S 33° 50´E | Lr CBr |
| Lower Mlunguzi River Mt Zomba S.Malawi 1000m 15° 22.6´S 35° 19.4´E | Lr Mlunguzi |
| Luchenza Rd. Thyolo Dist. S.Malawi. 800m. 16° 02´S 35° 14´E | |
| Lukonkhomwe River. Near Ekwendeni. Rumphi Dist. N.Malawi. 1125m. 11° 17´S 33° 53´E | Lukon |
| Lukwe Lodge Livingstonia Rumphi Dist N.Malawi 1140m 10° 35.1´S 34° 07.7´E | Lukwe |
| Lunyangwa Swamp Mzuzu Mzimba Dist. N.Malawi 1250m 11° 26.2´S 34° 01´E | Lunyangwa Swp |
| Lupaso Mzuzu Mzimba Dist. N.Malawi 1300m 11° 25´S 33° 58´E | Lupaso |
| Luselo River Bridge Nyika Nat. Pk. N.Malawi 1850m 10° 42´S 33° 39.7´E | Luselo |
| Luwawa Rd. Perekezi Forest. Mzimba Dist. N.Malawi. 1670m. 12° 05´S 33° 40´E | Luwawa |
| Mafinga Mtns. Chitipa Dist. N.Malawi. 2100m 9° 56´S 33° 22´E | Mafingas |
| Maiwale | |
| Makanga. Nr Chiromo. Nsanje Dist. S.Malawi. 100m 16° 30´S 35° 10´E | Makanga |
| Makuzi Beach Lodge Nkhata Bay Dist N.Malawi 480m 11° 55.1´S 34° 10.7´E | Makuzi |
| Malawe Hills. Nsanje. Dist. S Malawi. see Mt Malawi & Matandwe Forest Reserve | Malawi Hills |
| Malosa Forest Reserve, Machinga Dist. S. Malawi, 1150m 15° 12.2´S 35° 19.8´E | Malosa |
| Manchewe Falls. Livingstonia. Rumphi Dist. N.Malawi. 1000m 10° 35´S 34° 07´E | Manchewe |
| Mangochi. S.Malawi. 480m 14° 29´S 35° 15´E | Mangochi |
| Mangochi Fort Mangochi Dist. S Malawi 1368m 14° 26.7´S 35° 28.9´E | Man Ft |
| Manyanjere forest Zambia Nyika N.P. 2080m 10° 35´S 33° 39´E | Manyanjere |
| Matambe Hill Deep Bay Karonga Dist. N.Malawi 600m 10° 26´S 34° 15´E | Matambe Hill |
| Matandwe Forest Reserve Nsanje Dist. S.Malawi 240m 16° 52´S 35° 40´E | Matandwe |
| Mbota Lodge Chitimba Bay Rumphi Dist N.Malwi 480m 10° 37.2´S 34° 11.6´E | Mbota |
| Mbulunji Rumphi Dist. N.Malawi. 1200m 10° 49´S 34° 00´E | Mbulunji |
| Mchinji Mtn. = Fort Jameson C.Malawi. 1750m. 13° 43'S 32° 53'E | Mchinji Mt |
| Michiru Forest Res. Blantyre Dist. S.Malawi 1100m 16° 43´S 34° 59´E | Muchiru |
| Minunu Hut Mt Mulanje Plateau S.Malawi 2020m 15° 55.5´S 35° 38.4´E | Minunu |
| Mitsidi Hill Blantyre S. Malawi 1000m 15° 47.5´S 34° 58.5E | Mitssidi Hill |
| Mirale Railway Station | Mirale Rlwy |
| Mirale River Zomba Dist. S.Malawi 900m 15° 15.6´S 35° 15´E | Mirale R |
| Mkuwazi Forest Reserve. Nkhata Bay Dist. N.Malawi. 560m. 11° 41´S 34° 15´E | Mkw |
| Mlunguzi River. Mt. Zomba Plateau. (Trout farm) S.Malawi. 1500m 15° 21.3´S 35° 18.1´E | Mlunguzi R |
| Mondwe Valley. Karonga Dist. Nyika Nat. Pk. N.Malawi 1500m. 10° 21´S 33° 50´E | Mondwe |
| Monkey Bay. Mangochi Dist. S.Malawi. 480m. 14° 05´S 34° 55´E | Monkey Bay |
| Mpatamanga Forest. Neno Dist. S.Malawi. 270m. 15° 42´S 34° 43´E | Mpat |
| Mpindika River. Karonga Dist. Nyika Nat Pk. N.Malawi. 1300m. 10 °14´S 33° 47´E | Mpindika R |
| Mponela Lilongwe Dist. C.Malawi 1200m 13° 33´S 33° 45´E | Mponela |
| Mpopoti Turn Off Nyika N.P. N.Malawi 10° 31´S 33° 43´E | Mpopoti TO |
| Mtangatanga Forest Reserve. Mzimba Dist. N.Malawi. 1615m 11° 55.7´S 33° 42´E | Mtang |
| Mt Lwnjati Mzimba Dist. N. Malawi 1820m 12° 22´S 33° 42´E | Luwanjati Mtn |
| Mt Malawi Nsanje Dist. S.Malawi 870m 16° 55´S 35° 11´E | Mt Mal |
| Mt Mangochi Mangochi Dist. S. Malawi 1683m 14° 27.7´S 35° 29.26´E | Mt Man |
| Mt. Soche. Blantyre Dist. S.Malawi. 1530m 15° 50´S 35° 03´E | Sochi Mtn |

| Site | Abbreviation |
|---|---|
| Mtungulutsi River  Mt Zomba  S. Malawi  1170m  15° 19.2´S  35° 59.8´E | Mtungulutsi R |
| Mua Forest Reserve.  Dedza Dist.  C.Malawi.  680m.  15° 19´S  34° 30´E | Mua |
| Mubanga Forest Reserve.  Chitipa Dist.  N.Malawi.   1300m   9° 49´S  33° 21´E | Mubanga FR |
| Mugesse Forest Reserve (Bottom).  Misuku Hills.  Chitipa Dist.  N.Malawi.  1540m.  9° 40´S  33° 33´E | Mug |
| Mugesse Forest Reserve (Top).  Misuku Hills.  Chitipa Dist.  N.Malawi.  1830m.  9° 39´S  33° 32´E | Mug |
| Mulanje.  S.Malawi.  700m.  16° 05´S  35° 29´E | Mul |
| Mushitu Forest.  Dzalanyama Range.  Lilongwe Dist.  C.Malawi.  1600m  14° 28´S  33° 35´E | KR |
| Mwanda Mtn Ridge  Nyika N.P.  N.Malawi  1970m  10° 40´S  35´E | Mwanda Mtn |
| Mwanda Turn Off forest  Nyika N.P.  N.Malawi  10° 40´S  37°E | Mwanda TO |
| Mwasizi  Rumph Dist. N.Malawi  1250m  10° 54´S  33° 34.9´E | Mwasizi |
| Mvai Mtn  Ntcheu Dist.  C. Malawi  1880m   14° 21.4´S  34° 36´E | Mvai Mtn |
| Mvera Hill  Lilongwe Dist.  C.Malawi   1250m  13° 44´S  34° 6.8´E | Mvera Hill |
| Mvuu Lodge.  Liwonde Nat. Pk.  C.Malawi.  480m.  15° 54´S  35° 18´E | Mvuu Lodge |
| Mwabvi Game Reserve.  Nsanje Dist.  S.Malawi.  135m.  16° 39´S  35° 03´E | MGR |
| Mwenemisuku  Misuku Hills  Chitipa Dist.  N.Malawi  1250m  9° 45´S  33° 34´E | Mwenemisuku |
| Mwenewisi.  see Karonga North Forest. | Mwen |
| Mzinga River  Uzumara Village  Rumphi Dist.  N. Malawi  1430m  10° 54´S  34° 06.5´E | Mzinga R |
| Nanthana | |
| Nchenachena.  Rumphi Dist.  N.Malawi.  1200m   10° 45´S  34° 01´E | Nchenachena |
| Ndirande Mtn.  Blantyre Dist. S.Malawi.  1600m   15° 45´S  35 °03´E | Ndirande Mtn |
| Nganda  Nyika Nat. Pk.  N.Malawi  2600m  10° 26.6´S  33° 50.8´E | Nganda |
| Ngara Forest Reserve  Kasungu Dist.  C. Malawi  1300m  13° 19´S  33° 34.2´E | Ngara FR |
| Ngerenge  Karonga Dist.  N.Malawi  490m  9° 46´S  33° 51.5´E | Ngerenge |
| Nkhata Bay  N. Malawi  500m  11° 36.2´S  34° 17.5´E | N Bay |
| Nkhata Bay Hospital Bridge  N Malawi  550m  11° 35.8´S  34° 17.4´E | N Bay Hosp Br |
| Nkhorongo.  Suburb of Mzuzu.  N.Malawi.  1375m.  11° 23´S  33° 59´E | Nk or Mzuzu |
| Nkhotakota.  C.Malawi.  500m.  12° 55´S  34° 19´E | Nkhotakota |
| Nkhotakota Game Reserve  C.Malawi  530m  12° 47´S  34° 11´E | NGR |
| Nkudzi Bay.  Mangochi Dist.  S.Malawi.  480m.  14° 10.4´S  34° 59.9´E | Nkudzi |
| Ntcheu Mountain.  Ntcheu Dist.  C.Malawi  1500m   15° 49´S  34° 36´E | Ntcheu Mtn |
| Ntchisi Forest Reserve.  (top)  Ntchisi Dist.  C.Malawi.  1550m.  13° 19´S  34° 03´E | Ntchisi |
| Ntchisi Forest Reserve   (bottom)  Ntchisi Dist.  C. Malawi  1430m  13° 22´S  34° 00´E | Ntchisi |
| Nthwenzulu Hills.  Nr. Usisya.  Nkhata Bay Dist.  N.Malawi.  1200m   11° 13´S  34° 10´E | Nthwenzulu Hills |
| Nsanje.  = Port Herald  S.Malawi.  100m.  16° 55´S  35° 15´E. | Nsanje |
| Nthondwe  see Thondwe | |
| Nyamkhowa Mtn.  Nr. Livingstonia.  N.Malawi.  2100m.  10° 34´S  34° 05´E | Nyam |
| Nyungwe  Chiradzulu Dist.  S.Malawi.  1000m   15° 37´S  35° 10´E | Nyungwe |
| Perekezi Forest Reserve.  Mzimba Dist.  N.Malawi.  1600m   12° 03´S  33° 38´E | Perekeze |
| Phalombe.  Nr Mt Mulanje.  S.Malawi.  800m   15° 48´S  35° 38´E | Phalombe |
| Port Herald  -  see Nsanje | |
| Ramas Camp.  Lake Malawi.  (No data) | |
| Rumphi.  N.Malawi.  1100m  11° 01´S  33° 51´E | Rumphi |
| Ruo River.  Mt.Mulanje.  S.Malawi.  950m.  15° 58´S  35° 39´E | Ruo |
| Sawi River.  Nyika Nat. Pk.  Karonga Dist.  N.Malawi.  1155m.  10° 18.7´S  33° 52.5´E | Sawi |

| Site | Abbreviation |
|---|---|
| Salima. C.Malawi. 500m. 13° 45´S 34° 30´E | Salima |
| Sani Nr. Nkhotakota. C. Malawi. 500m. 13° 01´S 34° 18´E | Sani |
| Sekwa River. Nr.Wenya. Chitipa Dist. N.Malawi. 1350m. 10° 05´S 33° 34´E | Sekwa |
| Senga Bay Forest Reserve Salima Dist. C.Malawi. 480m. 13° 43´S 34° 37´E | SBFR |
| Sonjo Hill Mzimba Dist. N.Malawi 1400m 11° 24.5´S 33° 47.3´E | Sonjo Hill |
| Sorgin. Nsanje Dist. S.Malawi. 100m 16° 34´S 35° 00´E | Sorgin |
| S. Rukuru River Bridge Rumphi N.Malawi 1070m 11° 01´S 33° 49´E | S Rukuru Br |
| Tambani Forest Reserve Mwanza Dist. S.Malawi 720m 15° 38´S 34° 28´E | Tambani |
| Thazima Gate. Nyika Nat. Pk. N.Malawi. 1630m. 10° 50´S 33° 35´E | T Gate |
| Therere Forest Reserve. Chitipa Dist. N.Malawi. 1540m 10° 24´S 33° 54´E | TFR |
| Thondwe Zomba Dist. S Malawi 1000m 15° 28´S 35° 14´E | Thondwe |
| Thukutu River. Nr Dunduzu. Mzuzu. N.Malawi. 1230m. 11° 22´S 33° 56´E | Thukutu |
| Thyolo Mt. Forest Reserve Thyolo Dist. S.Malawi 1460m 16° 04´S 35° 03´E | Thyolo |
| Uledi. Nyika Nat. Pk. Karonga Dist. N.Malawi. 940m. 10° 10´S 33° 49´E | Uledi |
| Uyuzi Hill Vwaza Marsh Game Res. Mzimba Dist N.Malawi 1150m 11° 09´S 33° 35´E | Uyuzi |
| Uzumara Forest Reserve. Rumphi Dist. N.Malawi. 1960m. 10° 52´S 34° 08´E | Uz |
| Uzuzu Hill. Namizuma Forest. Mangochi Dist. 1050m. 14° 24.8´S 35° 22.7´E | Uzuzu |
| Vinthukutu Forest Reserve. Nr Chirumba. Karonga Dist. N.Malawi. 600m. 10° 24´S 34° 12´E | Vint |
| Vwaza Marsh Game Reserve. Mzimba Dist. N.Malawi. 1150m. 11° 09´S 33° 35´E | VMGR |
| Vwaza Marsh Game Reserve Chalepweleka Bridge Rumphi Dist N.Malawi 1120m 11° 08´S 33° 32.2´E | Chale |
| Willindi Forest Reserve. Chitipa Dist. N.Malawi. 1940m 9° 40´S 33° 27´E | Willindi |
| Zambia Nyika Nat. Pk. Km8 from Chelinda Turn off to Kaperikezi gate 2200m 10° 34´S 33° 40´E | ZNNP |
| Zaro Camp Vwaza Marsh Game Res. Mzimba Dist. N.Malawi 1130m 11° 11.7´S 33° 28.4´E | Zaro |
| Zavochepolwe Forest. Nyika Nat.Pk N.Malawi. 2250m. 10° 34´S 33° 42´E. | ZCF |
| Zomba Forestry Research Stn. Zomba Malawi 1000m 15° 22´S 35° 19´E. S. | FRIM |
| Zomba Trout Farm. Mt Zomba S. Malawi 1500m 15° 21.3´S 35° 18.1´E | ZTF |
| Zomba Mtn. peak S. Malawi 2085m 15° 20.45´S 35° 16´E | ZPk |
| Zomba Plateau. S.Malawi. 1900m. 15° 19.5´S 35 °17´E | Z Plat |
| Zungwara Bridge Nyika Nat. Pk. Chitipa Dist. N. Malawi 2080m 10° 31´S 33° 43.5´E | Zungwara |

# Appendix 4: Amphibians & Reptiles

## A: Amphibians

**Coordinates for amphibians recorded during the dry season survey**

| LATITUDE | LONGITUDE | ALTITUDE | |
|---|---|---|---|
| 16°18’53.0”S | 34°58’11.6”E | 58 | *Afrixalus fornasini* |
| 16°22’03.6”S | 35°02’09.1”E | 52 | *Afrixalus fornasini* |
| 16°15’08.6”S | 34°51’46,1”E | 80 | *Afrixalus fornasinii* |
| 16°14’53.8”S | 34°51’34.7”E | 75 | *Amietophrynus gutturalis* |
| 16°35’06.5S” | 35°04’39.9”E | 70 | *Chiromantis xerampelina* |
| 16°14’53.8”S | 34°51’34.7”E | 75 | *Hyperolius marmoratus taeniatus* |
| 16°15’08.6”S | 34°51’46,1”E | 80 | *Hyperolius marmoratus taeniatus* |
| 16°12'54.6"S | 34°47'03.5"E | 58 | *Phrynobatrachus cf mababiensis* |
| 16°14’53.8”S | 34°51’34.7”E | 75 | *Phrynobatrachus natalensis* |
| 16°21’39.2”S | 35°04’48.6”E | 52 | *Phrynobatrachus natalensis* |
| 16°31’1.20”S | 35°04’41.9”E | 75 | *Phrynobatrachus natalensis* |
| 16°16’43,2”S | 35°03’29.3”E | 88 | *Pyxicephalus edulis* |
| 16°12'54.6"S | 34°47'03.5"E | 58 | *Schismaderma careens* |
| 16°15’08.6”S | 34°51’46,1”E | 80 | *Xenopus muelleri* |

**Coordinates for amphibians recorded during wet season survey**

| LATITUDE | LONGITUDE | ALTITUDE | AMPHIBIAN SPECIES NAME |
|---|---|---|---|
| 16°12'00.4"S | 34°47'05.3"E | 100 | *Chiromantis xerampelina* |
| 16°33’07.3”S | 35°08’26.8”E | 48 | *Chiromantis xerampelina* |
| 16°12'54.6"S | 34°47'03.5"E | 58 | *Hildebrandtia ornate* |
| 16°33’07.3”S | 35°08’26.8”E | 48 | *Hyperolius argus* |
| 16°10'14.6"S | 34°51'40.2"E | 83 | *Hyperolius tuberilingus* |
| 16°10'11.5"S | 34°51'57.8"E | 81 | *Phrynobatrachus natalensis* |
| 16°10'11.5"S | 34°51'57.8"E | 81 | *Phrynobatrachus natalensis* |
| 16°10'14.6"S | 34°51'40.2"E | 83 | *Phrynobatrachus natalensis* |
| 16°10'14.6"S | 34°51'40.2"E | 83 | *Phrynobatrachus natalensis* |
| 16°12'54.6"S | 34°47'03.5"E | 58 | *Phrynobatrachus natalensis.* |
| 16°12'00.4"S | 34°47'05.3"E | 100 | *Phrynomantis bifasciata* |
| 16°12'54.6"S | 34°47'03.5"E | 58 | *Phrynomantis bifasciatus* |
| 16°12'54.6"S | 34°47'03.5"E | 58 | *Ptychadema mossambica* |
| 16°10'14.6"S | 34°51'40.2"E | 83 | *Ptychadena mossambica* |
| 16°12'54.6"S | 34°47'03.5"E | 58 | *Ptychadena mossambica* |
| 16°12'54.6"S | 34°47'03.5"E | 58 | *Ptychadena oxyrhynchus* |
| 16°12'54.6"S | 34°47'03.5"E | 58 | *Pyxicephalus edulis* |
| 16°12'54.6"S | 34°47'03.5"E | 58 | *Schlerophrys maculate* |
| 16°11’47.7”S | 34°49’05.3”E | 90 | *Sclerophrys gutturalis* |

| | | | |
|---|---|---|---|
| 16°12'54.6"S | 34°47'03.5"E | 58 | *Sclerophrys gutturalis* |
| 16°12'54.6"S | 34°47'03.5"E | 58 | *Sclerophrys maculate* |
| 16°12'54.6"S | 34°47'03.5"E | 58 | *Tomopterna marmorata* |
| 16°12'54.6"S | 34°47'03.5"E | 58 | *Tomopterna marmorata* |
| 16°10'11.5"S | 34°51'57.8"E | 81 | *Xenopus muelleri* |
| 16°10'14.6"S | 34°51'40.2"E | 83 | *Xenopus muelleri* |

# B: Reptiles

**Coordinates for reptiles recorded during dry season survey**

| | LATITUDE | LONGITUDE | ALTITUDE | SPECIES |
|---|---|---|---|---|
| **LIZARD** | 16°16'43,2"S | 35°03'29.3"E | 88 | *Agama aculeate* |
| | 16°37'20.9"S | 35°09'49.2"E | 48 | *Agama armata* |
| | 16°16'14.3"S | 34°55'16.7"E | 62 | *Hemidactylus mabouia* |
| | 16°12'54.6"S | 34°47'03.5"E | 58 | *Hemidactylus platycephalus* |
| | 16°18'53.0"S | 34°58'11.6"E | 58 | *Lygodactylus capensis* |
| | 16°22'03.6"S | 35°02'09.1"E | 52 | *Lygodactylus capensis* |
| | 16°27'13.3"S | 35°09'01.5"E | 50 | *Trachylepis striata* |
| | 16°32'21.2"S | 35°03'59.4"E | 75 | *Trachylepis striata* |
| | | | | |
| **SNAKE** | 16°14'53.8"S | 34°51'34.7"E | 75 | *Boaedon capensis* |
| | 16°18'53.0"S | 34°58'11.6"E | 58 | *Boaedon capensis* |
| | 16°17'11.0"S | 35°03'35.2"E | 93 | *Naja mossambica* |
| | 16°34'46.4"S | 35°03'07.9"E | 87 | *Philtotamnus semivariegatus* |
| | | | | |
| **TERRAPIN** | 16°27'13.3"S | 35°09'01.5"E | 50 | *Pelusios* cf *subniger* |
| | | | | |
| **CROCODILE** | 16°22'03.6"S | 35°02'09.1"E | 52 | *Crocodylus niloticus* |
| | 16°27'13.3"S | 35°09'01.5"E | 50 | *Crocodylus niloticus* |

**Coordinates for reptiles recorded during wet season survey**

| | LATITUDE | LONGITUDE | ALTITUDE | SPECIES |
|---|---|---|---|---|
| **TERRAPINS** | 16°29'21.0"S | 34°52'36.8"E | 141 | *Pelomedusa subrufa* |
| | | | | |
| **LIZARDS** | 16°32'21.2"S | 35°03'59.4"E | 54 | *Agama armata* |
| | 16°33'07.3"S | 35°08'26.8"E | 48 | *Agama armata* |
| | 16°29'21.0"S | 34°52'36.8"E | 141 | *Chamaeleo dilepis* |
| | 16°12'16.9"S | 34°46'53.3"E | 98 | *Chondrodactylus turneri* |
| | 16°29'21.0"S | 34°52'36.8"E | 141 | *Chondrodactylus turneri* |
| | 16°32'21.2"S | 35°03'59.4"E | 54 | *Gerrhosaurus intermedius* |
| | 16°10'11.5"S | 34°51'57.8"E | 81 | *Hemidactylus mabouia* |

| | | | | |
|---|---|---|---|---|
| | 16°29’21.0”S | 34°52’36.8”E | 141 | *Lygodactylus capensis* |
| | 16°29’21.0”S | 34°52’36.8”E | 141 | *Panaspis* nov. sp. |
| | 16°05’43.6”S | 34°54’42.1”E | 102 | *Trachylepis margaritifer* |
| | 16°10'54.3"S | 34°51'26.4"E | 85 | *Trachylepis striata* |
| | 16°29’21.0”S | 34°52’36.8”E | 141 | *Trachylepis striata* |
| | 16°29’21.0”S | 34°52’36.8”E | 141 | *Trachylepis varia* |
| | 16°32’21.2”S | 35°03’59.4”E | 54 | *Trachylepis varia* |
| | 16°33’07.3”S | 35°08’26.8”E | 48 | *Trachylepis varia* |
| | 16°10'54.3"S | 34°51'26.4"E | 85 | *Varanus niloticus* |
| | 16°32’21.2”S | 35°03’59.4”E | 54 | *Varanus niloticus* |
| | | | | |
| **SNAKES** | 16°11’49.2”S | 34°48’09.8”E | 91 | *Afrotyphlops mucruso* |
| | 16°32’21.2”S | 35°03’59.4”E | 54 | *Afrotyphlops mucruso* |
| | 16°15’11.1”S | 34°51’49.0”E | 76 | *Boaedon capensis* |
| | 16°10'11.5"S | 34°51'57.8"E | 81 | *Crotaphopeltis hotamboeia* |
| | 16°10'14.6"S | 34°51'40.2"E | 83 | *Crotaphopeltis hotamboeia* |
| | 16°12'54.6"S | 34°47'03.5"E | 58 | *Hemirhaggheris nototaenia* |
| | 16°13’23.3”S | 34°51’01.2”E | 82 | *Naja annulifera* |
| | 16°33’22.8”S | 35°01’23.3”E | 80 | *Naja annulifera* |
| | 16°28’57.9”S | 34°53’13.3”E | 121 | *Natriciteres olivaeceus* |

# Appendix 5: Fish

**GPS location of sampling sites visited during the fieldwork period 2-13 November 2015. Surveys included sampling fisheries catches at beach landing and used fisheries-independent methods at sampling sites.**

| Location name | Location type | Longitude | Latitude | Elevation (m) |
|---|---|---|---|---|
| Buluwayo | Landings beach | 35.08 | -16.54 | 50.69 |
| Chambalo | Landings beach | 35.13 | -16.55 | 49.54 |
| Chimbuli | Landings beach | 35.12 | -16.54 | 52.08 |
| Chisamba | Landings beach | 35.09 | -16.53 | -6.91 |
| Chisomba | Landings beach | 35.16 | -16.62 | 57.37 |
| Gumbwa | Landings beach | 34.81 | -15.99 | 81.73 |
| Kadamela | Landings beach | 35.13 | -16.59 | 3.72 |
| Kaleso | Landings beach | 35.13 | -16.58 | 46.24 |
| Lisuli | Landings beach | 34.85 | -16.04 | 82.38 |
| Maele | Landings beach | 35.14 | -16.61 | 48.59 |
| Mchere | Landings beach | 34.89 | -16.14 | 91.86 |
| Mwala | Landings beach | 35.14 | -16.53 | 37.3 |
| Njale | Landings beach | 35.14 | -16.52 | 28.67 |
| Nkolimbo | Landings beach | 35.15 | -16.54 | 52.56 |
| Yolodani | Landings beach | 34.84 | -16.04 | 80.57 |
| Denis 02 | Sampling site | 34.86 | -16.25 | 77.15 |
| Denis 03 | Sampling site | 34.85 | -16.17 | 80.96 |
| Denis 04 | Sampling site | 34.75 | -15.91 | 99.77 |
| Denis 05 | Sampling site | 34.74 | -15.82 | 125.8 |
| Denis 06 | Sampling site | 34.72 | -15.81 | 209.22 |
| Denis 08 | Sampling site | 34.92 | -16.27 | 63.86 |
| Denis 09 | Sampling site | 34.91 | -16.1 | 88.19 |
| Denis 10 | Sampling site | 34.97 | -16.15 | 101.28 |
| Denis 11 | Sampling site | 35.06 | -16.28 | 105.27 |
| Denis 12 | Sampling site | 35.13 | -16.55 | 50.01 |

# Appendix 6: Birds

## A: Bird species recorded in the Elephant Marsh during the current study

**The 199 bird species recorded in the Elephant Marsh area during this study (7-15 March 2016). Common and scientific names, as well as species ordering, follow (Dowestt-Lemaire & Dowsett 2006). Information in the 'Status' column is drawn from Dowsett *et al.* (2016) and refers to the status in Malawi as a whole; codes refer to: A – Africa, B - Breeding record confirmed, E - locally Extinct including former breeding records, M - Migrant including on passage through this country, P - breeds in Palearctic, R – Resident, V – Vagrant, W - Winters (non-breeding season),? – Uncertain. The common names of the 68 species regarded as waterbirds for the purposes of this report are presented in bold text.**

| Common name | Scientific name | Status | Nchalo Sports Club | Nyala Park | Nchalo 'Focus' Wetland | Nchalo Sugar Estate | Kaombe Sugar Estate | Nyasa Wildlife Sanctuary | Microlight flights | Upper Marsh | Lower Marsh |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Little Grebe** | *Tachybaptus ruficollis* | RB | | | | | | | | | X |
| **White-breasted Cormorant** | *Phalacrocorax carbo* | RB | | | | | | | X | | X |
| **Reed Cormorant** | *Phalacrocorax africanus* | RB | | | X | X | | | X | X | X |
| **African Darter** | *Anhinga rufa* | RB | | | | X | | | X | | X |
| **Pink-backed Pelican** | *Pelecanus rufescens* | RB | | | | | | | X | | X |
| **Little Bittern** | *Ixobrychus minutus* | RB/PW | | | X | | | | X | | X |
| **Black-crowned Night Heron** | *Nycticorax nycticorax* | RB | X | | X | | X | | X | X | |
| **Common Squacco Heron** | *Ardeola ralloides* | R(B) | X | | X | | | | X | X | X |
| **Cattle Egret** | *Bubulcus ibis* | RB | X | | X | X | X | | X | X | X |
| **Green-backed Heron** | *Butorides striata* | RB | | X | X | | X | | | X | |
| **Black Egret** | *Egretta ardesiaca* | R(B) | | | X | | | | X | X | X |
| **Little Egret** | *Egretta garzetta* | R(B) | X | | X | | | | X | X | X |
| **Yellow-billed Egret** | *Egretta intermedia* | R(B) | | | | | | | X | | X |
| **Great White Egret** | *Egretta alba* | R(B) | | | X | | | | X | X | X |
| **Purple Heron** | *Ardea purpurea* | RB | X | | X | X | | | X | X | X |
| **Grey Heron** | *Ardea cinerea* | RB | X | | X | | | | X | X | X |
| **Black-headed Heron** | *Ardea melanocephala* | RB | X | | | X | | X | X | X | |
| **Goliath Heron** | *Ardea goliath* | RB | | | | | | | X | | X |
| **Hamerkop** | *Scopus umbretta* | RB | | X | X | | X | X | | | X |
| **Yellow-billed Stork** | *Mycteria ibis* | RB | | | | | | | X | | X |
| **Openbill Stork** | *Anastomus lamelligerus* | AMB/R? | X | X | X | X | X | | X | X | X |
| **Sacred Ibis** | *Threskiornis aethiopicus* | AMB/R? | X | | | X | | | X | X | X |
| **Glossy Ibis** | *Plegadis falcinellus* | R(B) | | | X | | | | X | X | X |

| Common name | Scientific name | Status | Nchalo Sports Club | Nyala Park | Nchalo 'Focus' Wetland | Nchalo Sugar Estate | Kaombe Sugar Estate | Nyasa Wildlife Sanctuary | Microlight flights | Upper Marsh | Lower Marsh |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hadada Ibis** | *Bostrychia hagedash* | RB | | X | | | | | | | |
| **African Spoonbill** | *Platalea alba* | RB | | | | | | | X | | |
| **Greater Flamingo** | *Phoenicopterus ruber* | AM | | | | | | | X | | |
| **Fulvous Tree Duck** | *Dendrocygna bicolor* | AMB/R? | | | | | | | X | X | X |
| **White-faced Tree Duck** | *Dendrocygna viduata* | RB | X | | X | | | | X | X | X |
| **Egyptian Goose** | *Alopochen aegyptiaca* | RB | | | | | | | X | | |
| **Spur-winged Goose** | *Plectropterus gambensis* | RB | | | X | | | | X | | X |
| **Knob-billed Duck** | *Sarkidiornis melanotos* | AMB/R? | | X | X | | | | X | | X |
| **Red-billed Teal** | *Anas erythrorhyncha* | RB/AM | X | | X | | | | X | | |
| **Hottentot Teal** | *Anas hottentota* | RB | | | | | | | X | | X |
| Black-shouldered Kite | *Elanus caeruleus* | RB | | | | X | | | | X | |
| Black Kite | *Milvus migrans* | AMB/PW | | | | X | | | | | |
| **African Fish Eagle** | *Haliaeetus vocifer* | RB | | X | | X | | X | X | X | X |
| Black-breasted Snake Eagle | *Circaetus pectoralis* | RB | | | | | | | X | | |
| Brown Snake Eagle | *Circaetus cinereus* | RB | | | | X | X | | | | |
| Western Banded Snake Eagle | *Circaetus cinerascens* | RB | | | | | | | X | | |
| Bateleur | *Terathopius ecaudatus* | RB | | | | | | | | | X |
| Gymnogene | *Polyboroides typus* | RB | X | | | | | | | | |
| **Eurasian Marsh Harrier** | *Circus aeruginosus* | PW | | | | X | | | | | |
| **African Marsh Harrier** | *Circus ranivorus* | RB | | | X | | | | | X | X |
| Pallid Harrier | *Circus macrourus* | PW | | | | | | | | | X |
| African Goshawk | *Accipiter tachiro* | RB | | X | | | | | | | |
| Wahlberg's Eagle | *Aquila wahlbergi* | AMB | | | | X | | X | | | |
| **Osprey** | *Pandion haliaetus* | PW | | | | | | | | | X |
| Eastern Red-footed Falcon | *Falco amurensis* | PW | X | X | X | X | | | | | |
| Red-necked Falcon | *Falco chicquera* | RB | X | | | | | | | | |
| Eurasian Hobby | *Falco subbuteo* | PW | | | | | | X | | | |
| Lanner Falcon | *Falco biarmicus* | RB | X | | | X | | | | | |
| Peregrine Falcon | *Falco peregrinus* | RB/PV | X | | | X | | | | | |
| Red-necked Francolin | *Francolinus afer* | RB | X | | X | | X | | | | |
| Helmeted Guineafowl | *Numida meleagris* | RB | | | | | X | | | | |
| **Black Crake** | *Amaurornis flavirostra* | RB | X | | X | | | | | | X |
| **Purple Gallinule** | *Porphyrio porphyrio* | RB | | | X | | | | X | X | X |
| **Lesser Gallinule** | *Porphyrio alleni* | AMB | | | X | | | | | | |
| **Common Moorhen** | *Gallinula chloropus* | RB | | | | | | | | | X |
| **African Jacana** | *Actophilornis africanus* | RB | | | X | X | | | X | X | X |
| **Lesser Jacana** | *Microparra capensis* | RB | | | | | | | | | X |

| Common name | Scientific name | Status | Nchalo Sports Club | Nyala Park | Nchalo 'Focus' Wetland | Nchalo Sugar Estate | Kaombe Sugar Estate | Nyasa Wildlife Sanctuary | Microlight flights | Upper Marsh | Lower Marsh |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Painted Snipe** | *Rostratula benghalensis* | RB | | | X | | | | | | X |
| **Black-winged Stilt** | *Himantopus himantopus* | RB | | | X | X | | | X | | X |
| **Avocet** | *Recurvirostra avosetta* | AM | | | | | | | X | | |
| **Water Dikkop** | *Burhinus vermiculatus* | RB | | | X | | X | | | | |
| **Common Pratincole** | *Glareola pratincola* | RB | | | | | | | X | | X |
| **Ringed Plover** | *Charadrius hiaticula* | PW | | | | | | | | | X |
| **Kittlitz's Plover** | *Charadrius pecuarius* | RB/AM | | | | | | | | | X |
| **Three-banded Plover** | *Charadrius tricollaris* | RB | | | X | | | | | | X |
| **Long-toed Plover** | *Vanellus crassirostris* | RB | | | | | | | X | X | X |
| **Black-tailed Godwit** | *Limosa limosa* | PV | | | | | | | | | X |
| **Marsh Sandpiper** | *Tringa stagnatilis* | PW | | | | | | | | | X |
| **Greenshank** | *Tringa nebularia* | PW | | | X | | | | X | X | X |
| **Wood Sandpiper** | *Tringa glareola* | PW | | X | X | X | | | X | X | X |
| **Common Sandpiper** | *Actitis hypoleucos* | PW | | X | X | X | | | | X | X |
| **Little Stint** | *Calidris minuta* | PW | | | X | | | | X | | X |
| **Curlew Sandpiper** | *Calidris ferruginea* | P | | | | | | | X | | X |
| **Ruff** | *Philomachus pugnax* | PW | | | X | | | | X | X | X |
| **Grey-headed Gull** | *Larus cirrocephalus* | RB | | | | | | | | | X |
| **Whiskered Tern** | *Chlidonias hybrida* | RB | | | X | | | | X | X | X |
| **White-winged Tern** | *Chlidonias leucopterus* | PW | | | | | | | X | | X |
| **African Skimmer** | *Rynchops flavirostris* | RB | | | | | | | X | | X |
| Laughing Dove | *Streptopelia senegalensis* | RB | | | X | X | X | | | | |
| African Mourning Dove | *Streptopelia decipiens* | RB | X | | X | X | | | | X | |
| Cape Turtle Dove | *Streptopelia capicola* | RB | | | | | | X | | | |
| Red-eyed Dove | *Streptopelia semitorquata* | RB | X | X | X | X | | X | | X | |
| Emerald-spotted Wood Dove | *Turtur chalcospilos* | RB | X | X | | | X | X | | | |
| Namaqua Dove | *Oena capensis* | AMB/RB | | | X | X | X | | | | |
| African Green Pigeon | *Treron calvus* | RB | X | | | | | | | | |
| Purple-crested Turaco | *Tauraco porphyreolophus* | RB | | X | | | | | | | |
| Jacobin Cuckoo | *Clamator jacobinus* | AM(B) | | X | | | | | | | |
| Klaas's Cuckoo | *Chrysococcyx klaas* | RB | | X | | | | | | | |
| Didric Cuckoo | *Chrysococcyx caprius* | AMB | | X | | | | | | | X |
| Green Coucal | *Ceuthmochares aereus* | RB | | X | | | | | | | |
| Burchell's Coucal | *Centropus superciliosus* | RB | | X | X | X | X | | | | |
| Barn Owl | *Tyto alba* | RB | X | | | | | | | | |
| Giant Eagle Owl | *Bubo lacteus* | RB | | X | | | | | | | |
| Gaboon Nightjar | *Caprimulgus fossii* | RB | | | | | | | | | X |

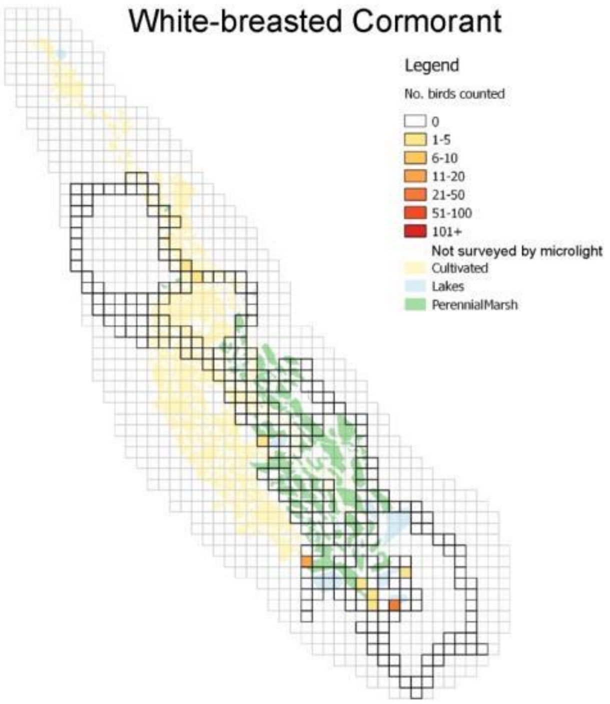
| Common name | Scientific name | Status | Nchalo Sports Club | Nyala Park | Nchalo 'Focus' Wetland | Nchalo Sugar Estate | Kaombe Sugar Estate | Nyasa Wildlife Sanctuary | Microlight flights | Upper Marsh | Lower Marsh |
|---|---|---|---|---|---|---|---|---|---|---|---|
| African Palm Swift | *Cypsiurus parvus* | RB | X | X | | X | X | | | X | |
| Eurasian Swift | *Apus apus* | PW | | | | | | | X | | |
| Little Swift | *Apus affinis* | RB | | | | | | | | X | |
| Speckled Mousebird | *Colius striatus* | RB | X | X | | | X | | | | |
| Red-faced Mousebird | *Urocolius indicus* | RB | | X | | | X | | | | |
| **Malachite Kingfisher** | *Alcedo cristata* | RB | | | X | | | | | X | X |
| Brown-hooded Kingfisher | *Halcyon albiventris* | RB | X | | | X | | | | | |
| Chestnut-bellied Kingfisher | *Halcyon leucocephala* | AMB | | X | | | | X | | | |
| Striped Kingfisher | *Halcyon chelicuti* | RB | X | | | | | | | | |
| **Giant Kingfisher** | *Megaceryle maxima* | RB | X | | | X | | | | | |
| **Pied Kingfisher** | *Ceryle rudis* | RB | | X | X | | | | X | X | X |
| Little Bee-eater | *Merops pusillus* | RB | | X | | | | X | | X | |
| Boehm's Bee-eater | *Merops boehmi* | RB | | X | | | | | | | |
| Blue-cheeked Bee-eater | *Merops persicus* | PW | X | X | X | X | X | X | | X | |
| Eurasian Bee-eater | *Merops apiaster* | PW/AM? | | X | | X | | X | | | |
| Southern Carmine Bee-eater | *Merops nubicoides* | AMB/R | | X | | X | X | X | | | |
| Eurasian Roller | *Coracias garrulus* | PW | | | | | X | | | | |
| Lilac-breasted Roller | *Coracias caudatus* | RB | | | | X | X | | | | |
| Scimitarbill | *Rhinopomastus cyanomelas* | RB | | X | | | | X | | | |
| Yellow-fronted Tinkerbird | *Pogoniulus chrysoconus* | RB | | | | | | X | | | |
| Golden-rumped Tinkerbird | *Pogoniulus bilineatus* | RB | | X | | | | | | | |
| Black-collared Barbet | *Lybius torquatus* | RB | | X | | | | X | | | |
| Lesser Honeyguide | *Indicator minor* | RB | | X | | | | | | | |
| Golden-tailed Woodpecker | *Campethera abingoni* | RB | | X | | | | X | | | |
| Cardinal Woodpecker | *Dendropicos fuscescens* | RB | | X | | | | | | | |
| Eurasian Sand Martin | *Riparia riparia* | PW | | | | X | | | | X | X |
| African Sand Martin | *Riparia paludicola* | RB | | | X | X | | | | | X |
| Grey-rumped Swallow | *Pseudhirundo griseopyga* | AMB | | | | X | | | | | |
| Lesser Striped Swallow | *Cecropis abyssinica* | RB | | | | X | | | | | |
| Wire-tailed Swallow | *Hirundo smithii* | RB | X | | X | X | X | | | X | |
| Eurasian Swallow | *Hirundo rustica* | PW | | | X | X | | X | | X | X |
| Eurasian House Martin | *Delichon urbicum* | PW | | | | X | X | | | | |
| **African Pied Wagtail** | *Motacilla aguimp* | RB | | X | | X | X | | | | |
| Richard's Pipit | *Anthus richardi* | RB | X | | X | X | | | | | |
| Yellow-throated Longclaw | *Macronyx croceus* | RB | | | X | X | | | | | |
| Sombre Bulbul | *Andropadus importunus* | RB | X | X | | | | X | | | |
| Yellow-bellied Bulbul | *Chlorocichla flaviventris* | RB | | X | | | | X | | | |

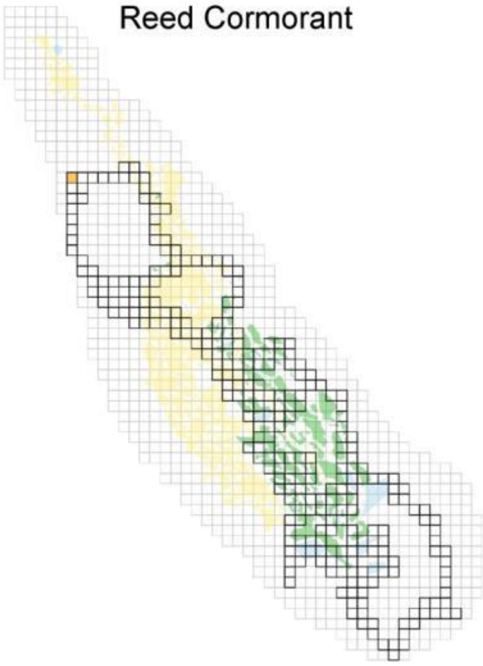
| Common name | Scientific name | Status | Nchalo Sports Club | Nyala Park | Nchalo 'Focus' Wetland | Nchalo Sugar Estate | Kaombe Sugar Estate | Nyasa Wildlife Sanctuary | Microlight flights | Upper Marsh | Lower Marsh |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Terrestrial Bulbul | *Phyllastrephus terrestris* | RB | | X | | | | X | | | |
| Black-eyed Bulbul | *Pycnonotus barbatus* | RB | X | X | | | | X | | | |
| Thrush Nightingale | *Luscinia luscinia* | PW | | X | | | | | | | |
| Heuglin's Robin | *Cossypha heuglini* | RB | X | X | | | X | X | | | |
| Collared Palm Thrush | *Cichladusa arquata* | RB | X | X | | | | | | | |
| Little Rush Warbler | *Bradypterus baboecala* | RB | | | X | | | | | X | |
| Sedge Warbler | *Acrocephalus schoenobaenus* | PW | | | X | | | | | | X |
| African Reed Warbler | *Acrocephalus baeticatus* | RB | | X | X | | | | | | |
| Marsh Warbler | *Acrocephalus palustris* | PW | | | X | X | | | | | |
| Great Reed Warbler | *Acrocephalus arundinaceus* | PW | | X | X | | | | | X | |
| Lesser Swamp Warbler | *Acrocephalus gracilirostris* | RB | | | X | X | | | | X | X |
| Burnt-necked Eremomela | *Eremomela usticollis* | RB | | X | | | | | | | |
| Long-billed Crombec | *Sylvietta rufescens* | RB | | X | | | | X | | | |
| Willow Warbler | *Phylloscopus trochilus* | PW | X | X | | | | | | | |
| Garden Warbler | *Sylvia borin* | PW | | X | | | | | | | |
| Rattling Cisticola | *Cisticola chiniana* | RB | X | X | | | X | X | | | |
| Red-faced Cisticola | *Cisticola erythrops* | RB | X | X | | X | | | | | |
| Greater Black-backed Cisticola | *Cisticola galactotes* | RB | | X | X | X | | | | X | |
| Tawny-flanked Prinia | *Prinia subflava* | RB | | X | X | | | X | | X | |
| Yellow-breasted Apalis | *Apalis flavida* | RB | X | X | | | | X | | | |
| Rudd's Apalis | *Apalis ruddi* | RB/E? | | X? | | | | | | | |
| Bleating Bush Warbler | *Camaroptera brachyura* | RB | | X | | | | X | | | |
| Spotted Flycatcher | *Muscicapa striata* | PW | | X | | | | | | | |
| Ashy Flycatcher | *Muscicapa caerulescens* | RB | | X | | | | | | | |
| Chinspot Batis | *Batis molitor* | RB | | X | | | | | | | |
| Black-throated Wattle-eye | *Platysteira peltata* | RB | | X | | | | | | | |
| African Paradise Flycatcher | *Terpsiphone viridis* | AMB/W | X | X | | | | | | | |
| Collared Sunbird | *Hedydipna collaris* | RB | | X | | | | | | | |
| Yellow-bellied Sunbird | *Cinnyris venustus* | RB | | X | | | | | | | |
| Purple-banded Sunbird | *Cinnyris bifasciatus* | RB | | X | | | | | | X | |
| Red-backed Shrike | *Lanius collurio* | PW | X | | | X | | X | | | |
| Brubru | *Nilaus afer* | RB | | X | | | | | | | |
| Southern Puffback | *Dryoscopus cubla* | RB | | X | | | | | | | |
| Brown-crowned Tchagra | *Tchagra australis* | RB | | X | | | | X | | | |
| Tropical Boubou | *Laniarius aethiopicus* | RB | | X | | | | X | | | |
| Orange-breasted Bush Shrike | *Telophorus sulfureopectus* | RB | | X | | | | | | | |
| Grey-headed Bush Shrike | *Malacanotus blanchoti* | RB | | X | | | | | | | |

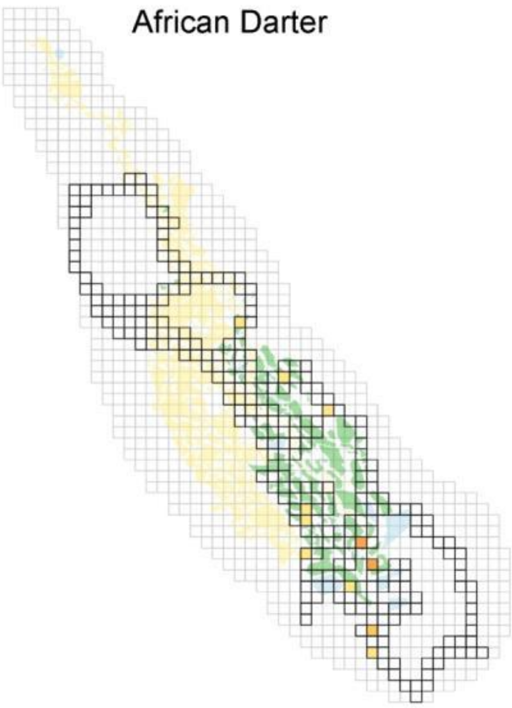
| Common name | Scientific name | Status | Nchalo Sports Club | Nyala Park | Nchalo 'Focus' Wetland | Nchalo Sugar Estate | Kaombe Sugar Estate | Nyasa Wildlife Sanctuary | Microlight flights | Upper Marsh | Lower Marsh |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fork-tailed Drongo | *Dicrurus adsimilis* | RB | | X | | | | | | | |
| Pied Crow | *Corvus albus* | RB | X | | | X | X | | | | |
| Greater Blue-eared Starling | *Lamprotornis chalybaeus* | RB | | X | | | | X | | | |
| Amethyst Starling | *Cinnyricinclus leucogaster* | AMB | | X | | | | | | | |
| House Sparrow | *Passer domesticus* | RB | X | X | | | | | | | |
| Southern Grey-headed Sparrow | *Passer diffusus* | RB | X | X | | | X | X | | | |
| White-browed Sparrow-Weaver | *Plocepasser mahali* | RB | | | | | X | X | | | |
| Spectacled Weaver | *Ploceus ocularis* | RB | X | X | | | | | | | |
| Southern Brown-throated Weaver | *Ploceus xanthopterus* | RB | X | X | X | | X | | | X | |
| Lesser Masked Weaver | *Ploceus intermedius* | RB | X | | | | | X | | | |
| Spotted-backed Weaver | *Ploceus cucullatus* | RB | | | | | X | X | | | |
| Dark-backed Weaver | *Ploceus bicolor* | RB | | X | | | | | | | |
| Thick-billed Weaver | *Amblyospiza albifrons* | RB | X | X | | | | | | X | |
| Red Bishop | *Euplectes orix* | RB | | X | X | | | X | | X | |
| Red-shouldered Whydah | *Euplectes axillaris* | RB | | | X | X | X | X | | | |
| Green-winged Pytilia | *Pytilia melba* | RB | | X | | | | X | | | |
| Red-billed Firefinch | *Lagonosticta senegala* | RB | | X | | | | X | | | |
| Blue-billed Firefinch | *Lagonosticta rubricata* | RB | | X | | | | | | | |
| Common Waxbill | *Estrilda astrild* | RB | | X | X | X | X | | | X | |
| Zebra Waxbill | *Amandava subflava* | RB | | | | | | X | | | |
| Blue Waxbill | *Uraeginthus angolensis* | RB | | X | | | | X | | | |
| Bronze Mannikin | *Lonchura cucullata* | RB | X | | | X | | | | | |
| Cut-throat Finch | *Amadina fasciata* | RB | X | | | | | X | | | |
| Village Indigobird | *Vidua chalybeata* | RB | | | | | | X | | | |
| Pin-tailed Widow | *Vidua macroura* | RB | X | X | X | X | X | X | | X | |
| Long-tailed Paradise Widow | *Vidua paradisaea* | RB | | X | | | X | X | | | |
| Yellow-eyed Canary | *Serinus mozambicus* | RB | X | X | | | | X | | | |
| Bully Canary | *Serinus sulphuratus* | RB | | | | X | | | | | |

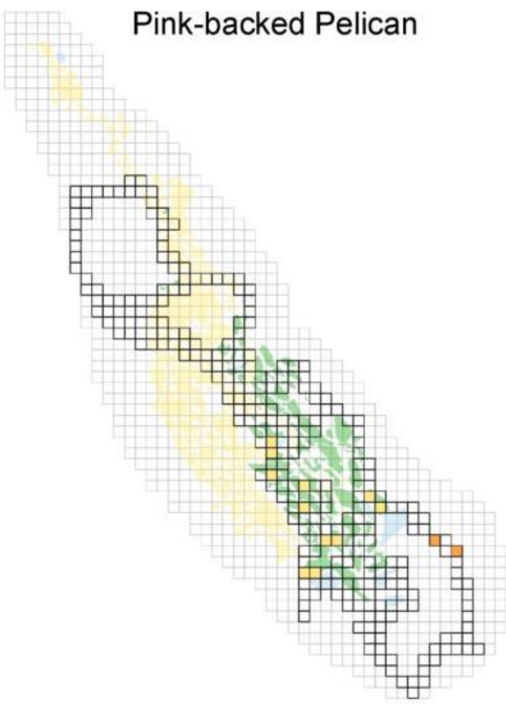
# B: Distribution maps

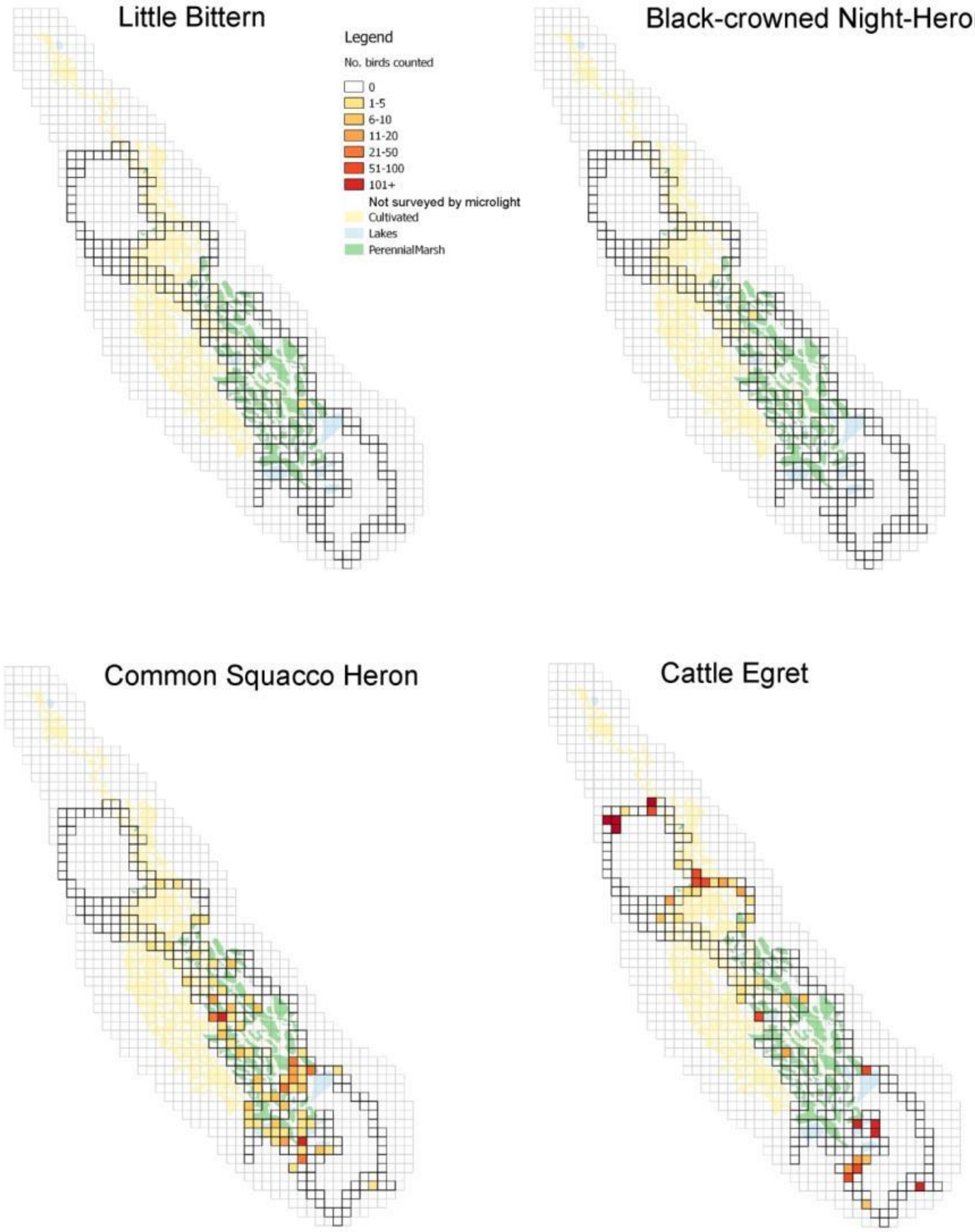
**Distribution maps for the 44 waterbirds species recorded during the two microlight flights on 9 and 10 March 2016.**

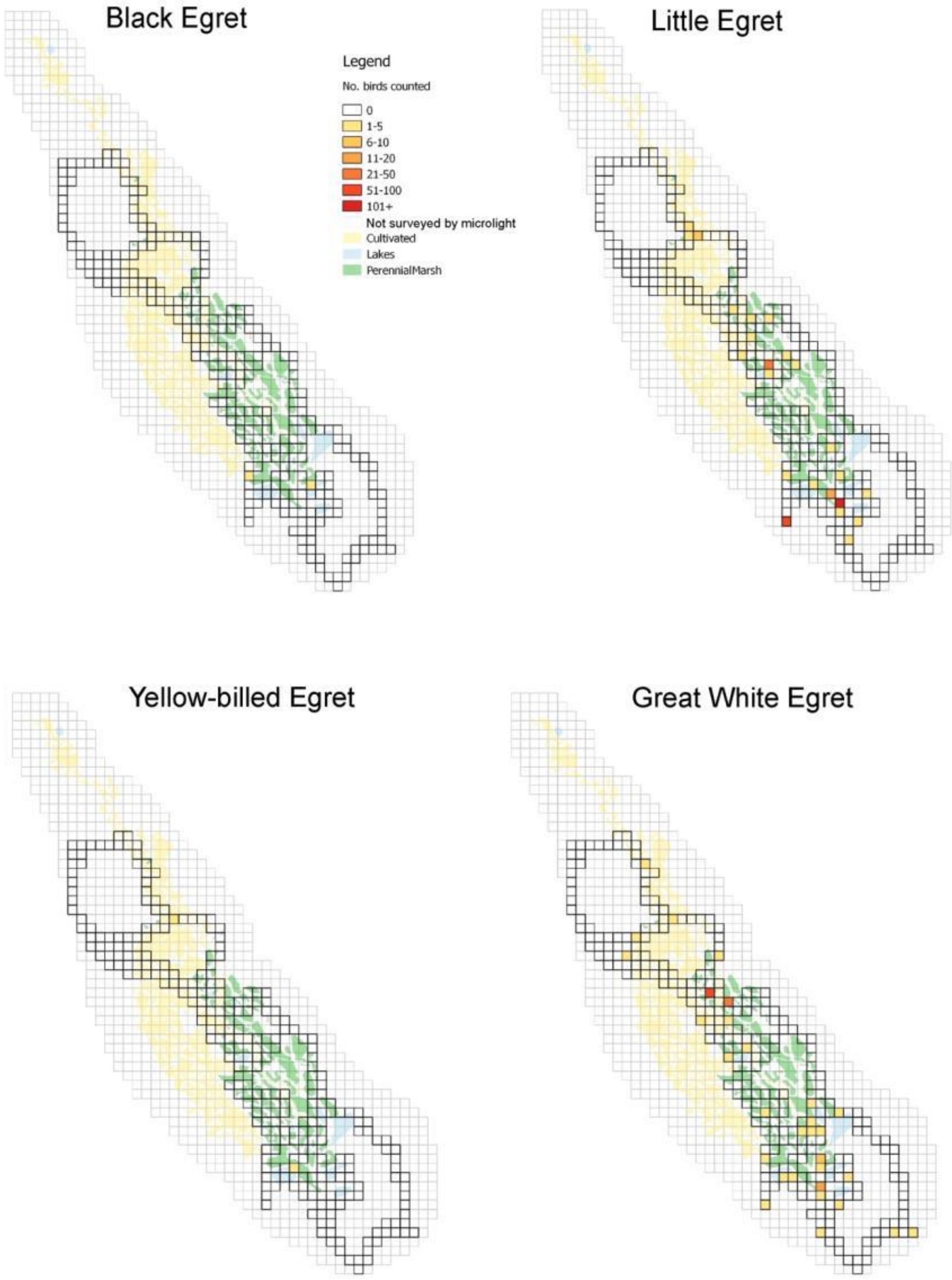


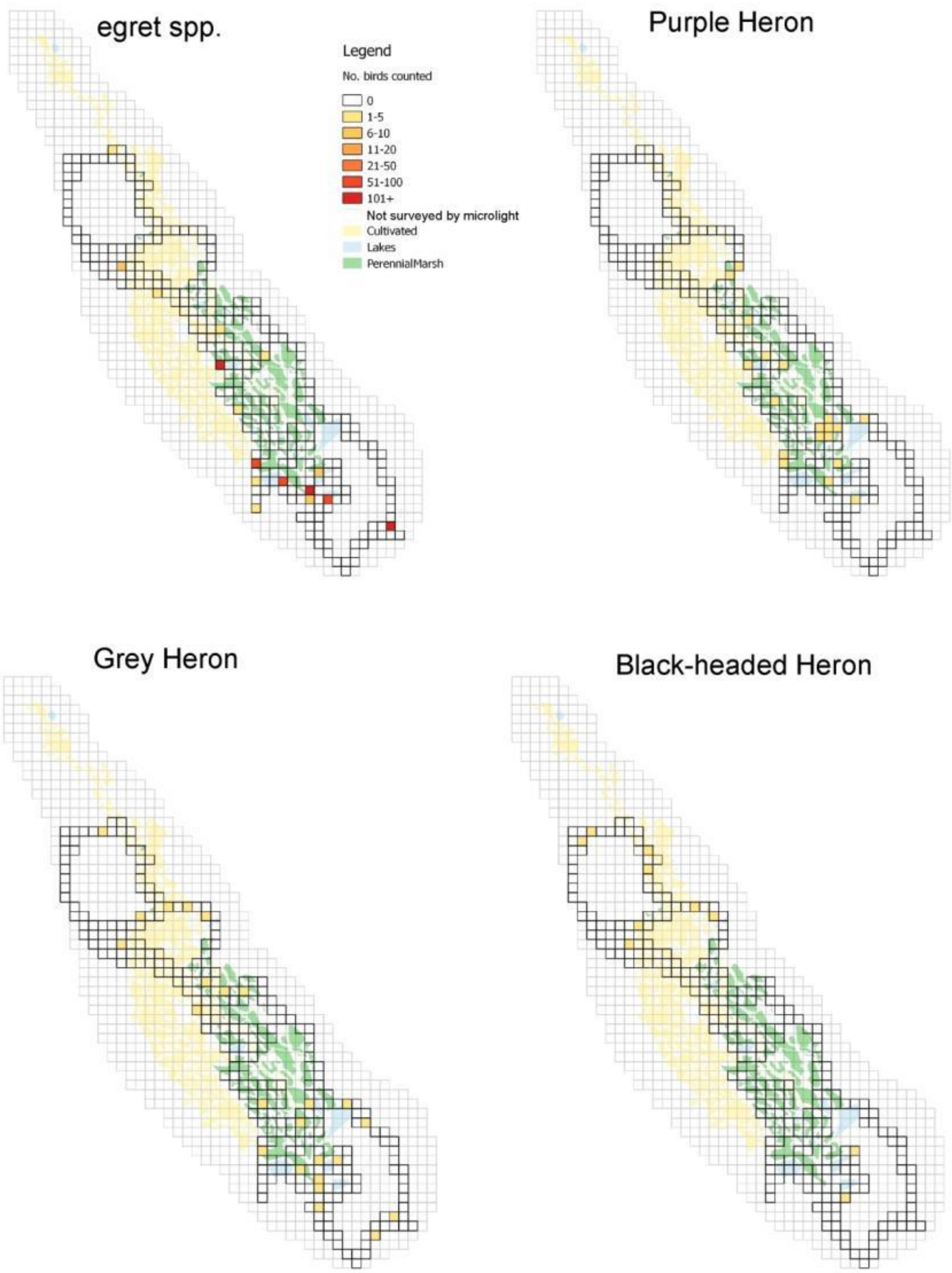



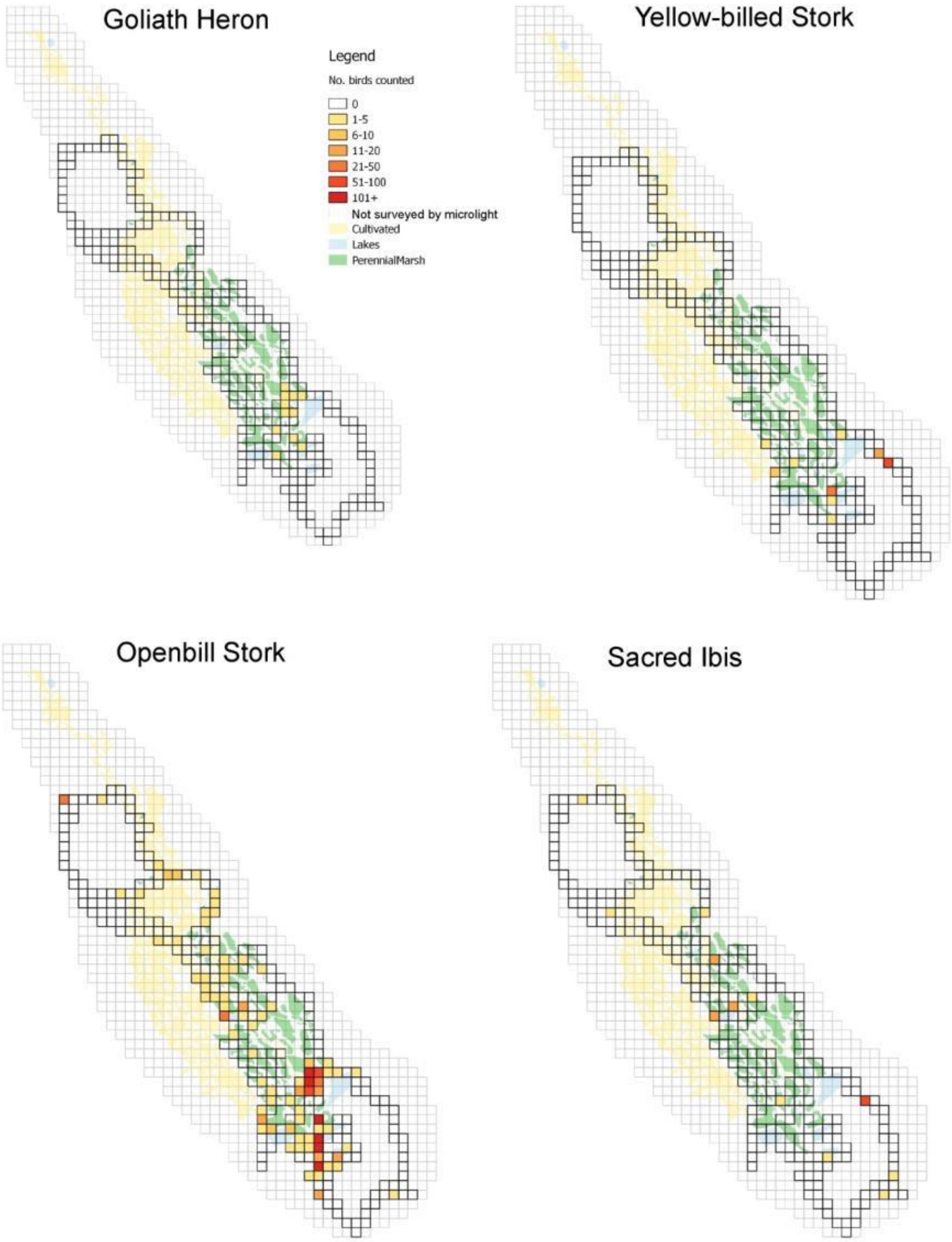



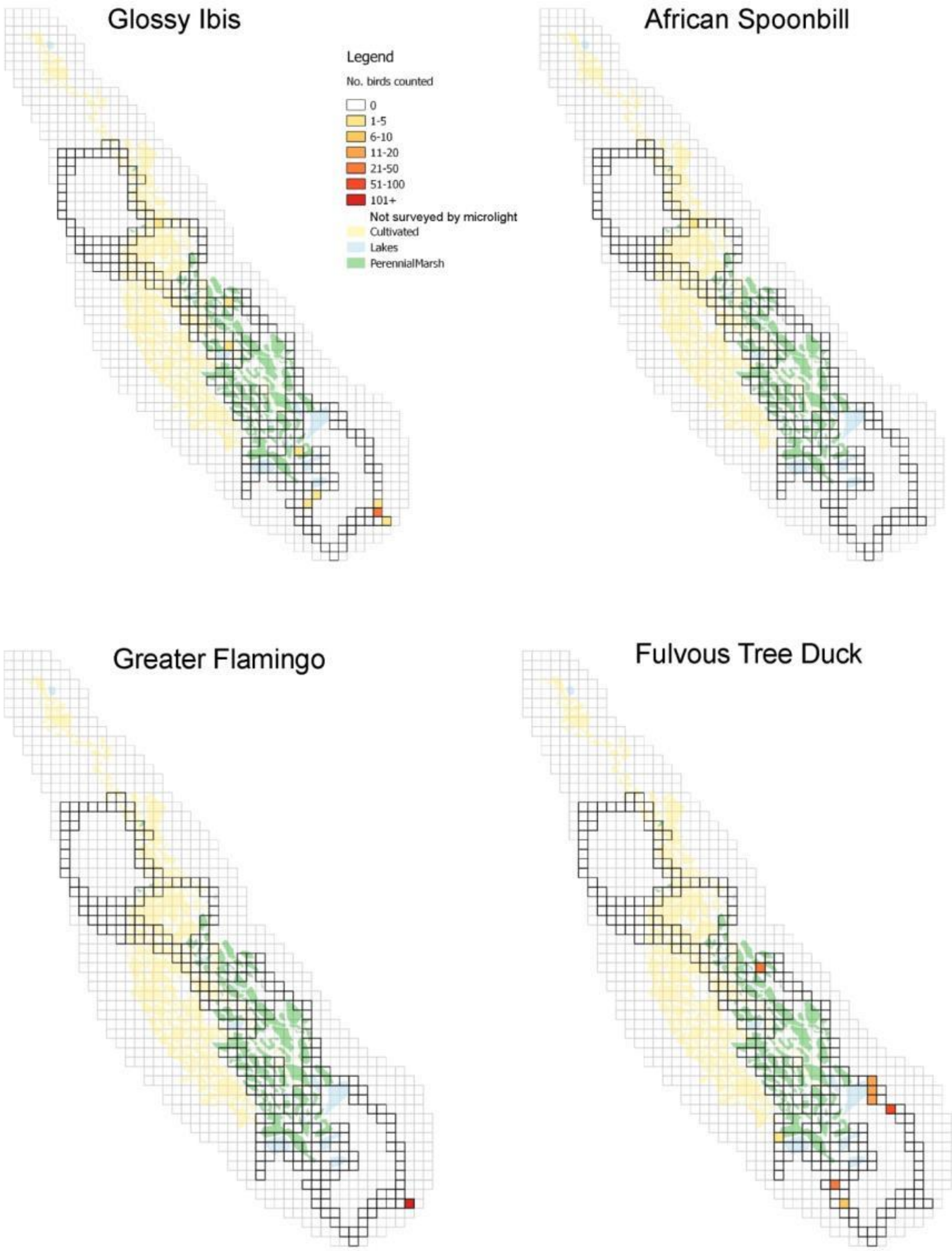



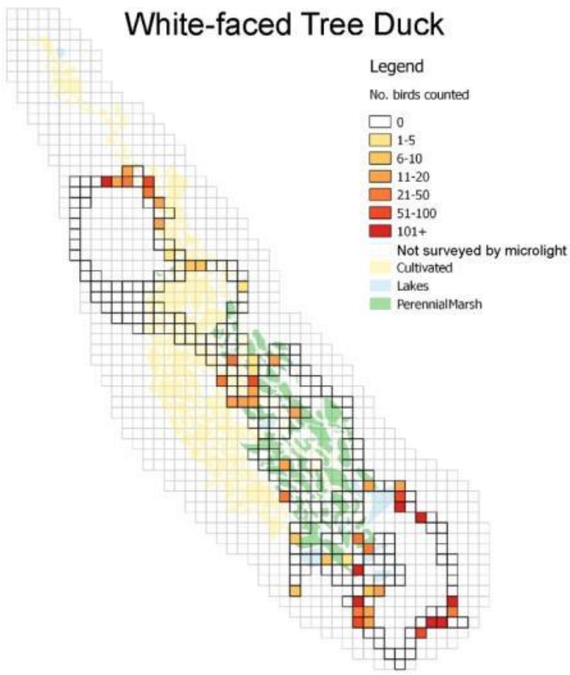

Little Bittern
Legend
No. birds counted
0
1-5
6-10
11-20
21-50
51-100
101+
Not surveyed by microlight
Cultivated
Lakes
PerennialMarsh
Black-crowned Night-Heron
Common Squacco Heron
Cattle Egret

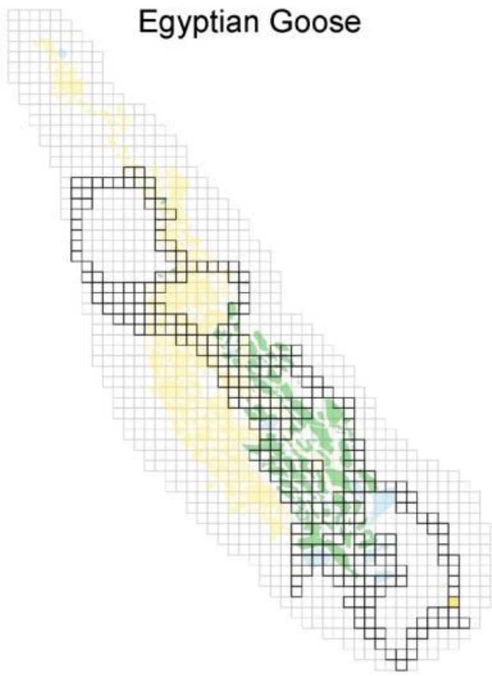

Black Egret
Little Egret
Legend
No. birds counted
0
1-5
6-10
11-20
21-50
51-100
101+
Not surveyed by microlight
Cultivated
Lakes
PerennialMarsh
Yellow-billed Egret
Great White Egret

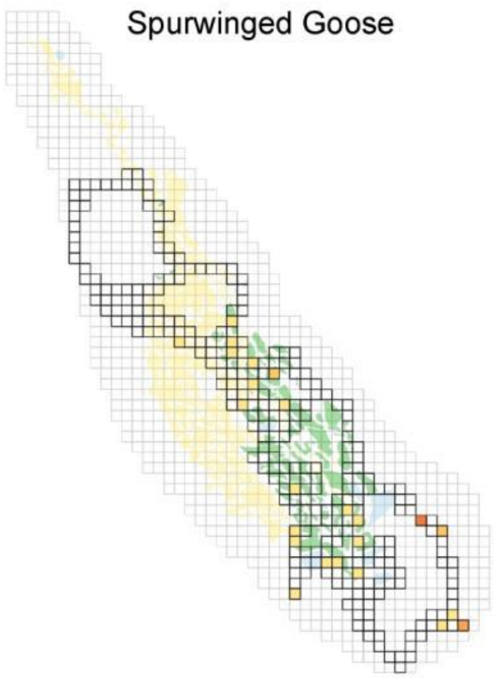

egret spp.
Legend
No. birds counted
0
1-5
6-10
11-20
21-50
51-100
101+
Not surveyed by microlight
Cultivated
Lakes
PerennialMarsh
Purple Heron
Grey Heron
Black-headed Heron

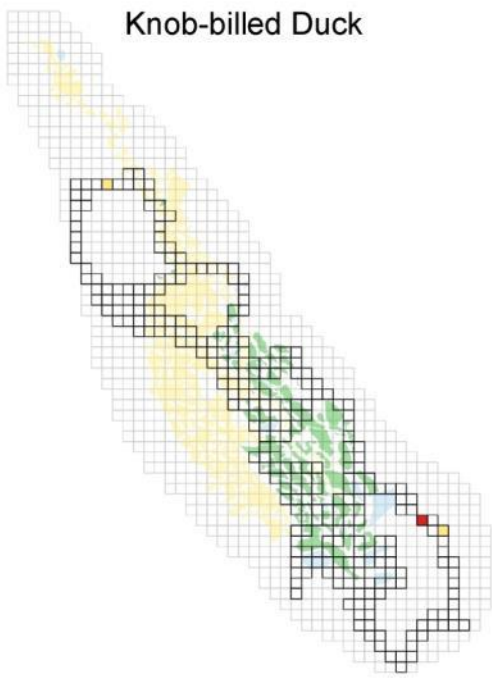

Goliath Heron
Legend
No. birds counted
0
1-5
6-10
11-20
21-50
51-100
101+
Not surveyed by microlight
Cultivated
Lakes
PerennialMarsh
Yellow-billed Stork
Openbill Stork
Sacred Ibis


Glossy Ibis
Legend
No. birds counted
0
1-5
6-10
11-20
21-50
51-100
101+
Not surveyed by microlight
Cultivated
Lakes
PerennialMarsh
African Spoonbill
Greater Flamingo
Fulvous Tree Duck

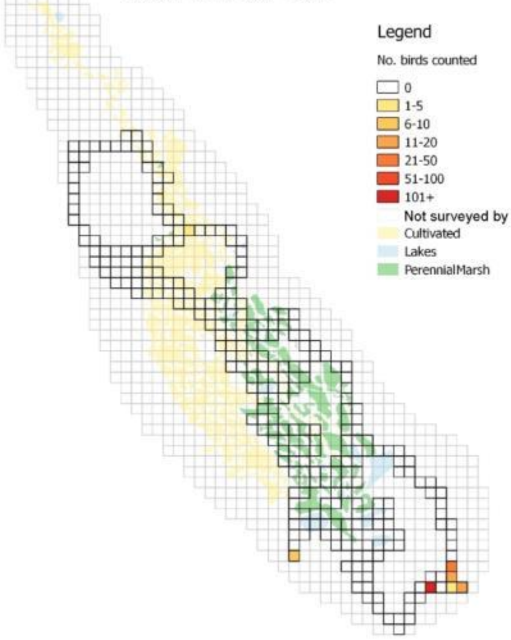

White-faced Tree Duck
Legend
No. birds counted
0
1-5
6-10
11-20
21-50
51-100
101+
Not surveyed by microlight
Cultivated
Lakes
PerennialMarsh


Egyptian Goose

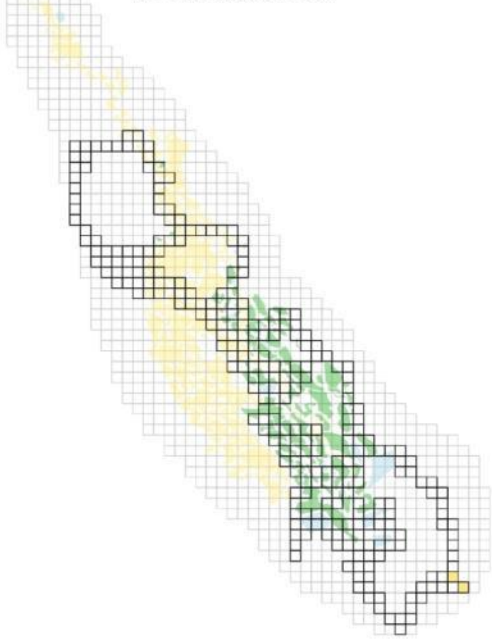

Spurwinged Goose


Knob-billed Duck

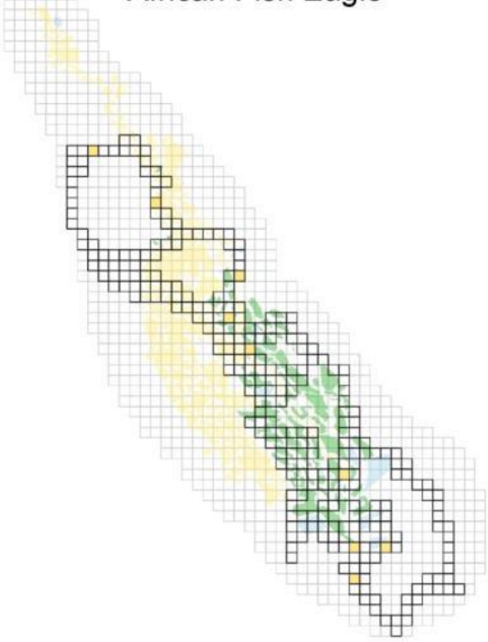
### Red-billed Teal



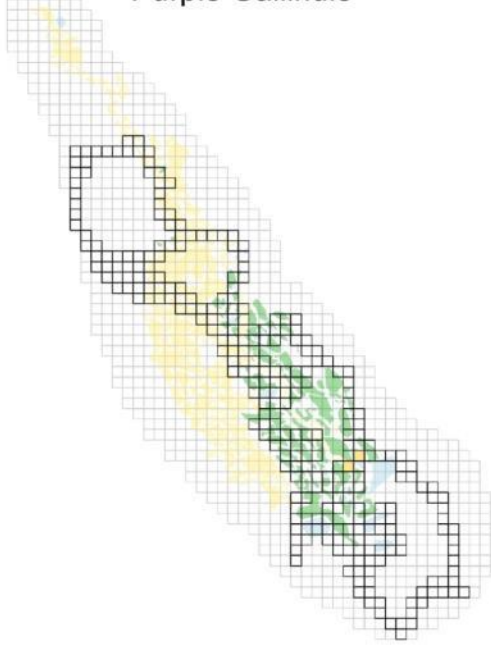

### Hottentot Teal

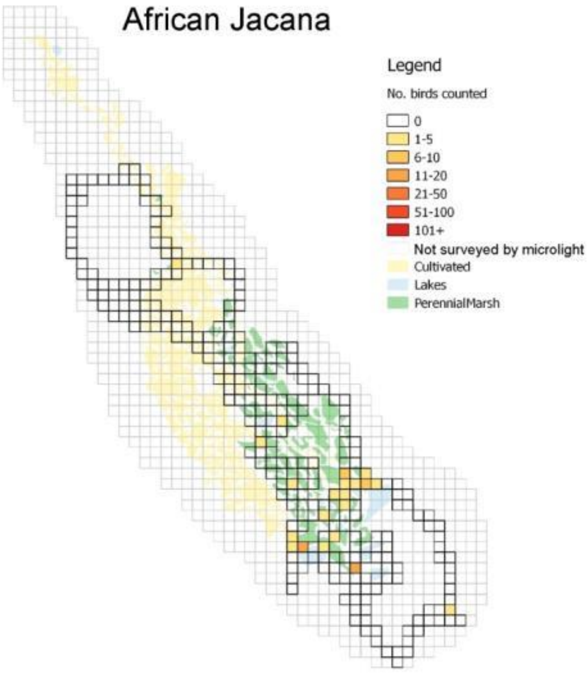


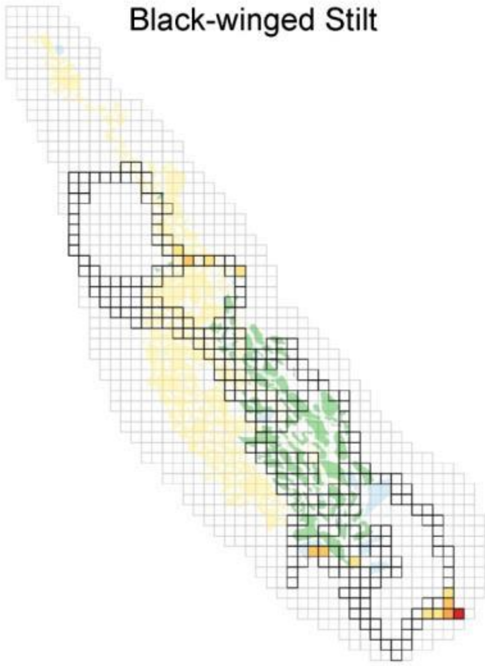
### African Fish Eagle

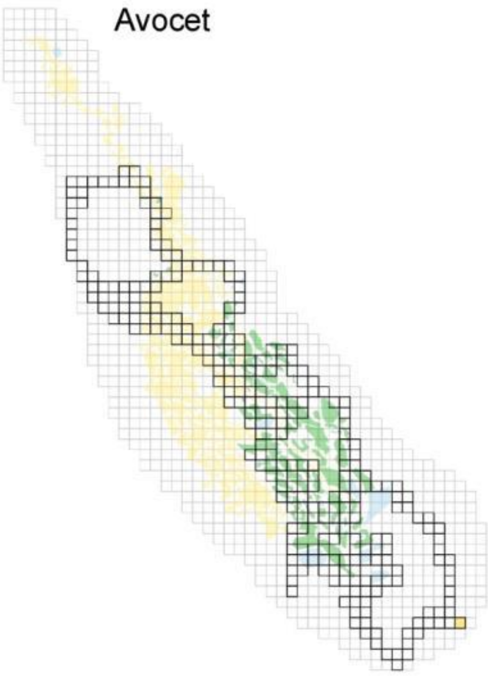


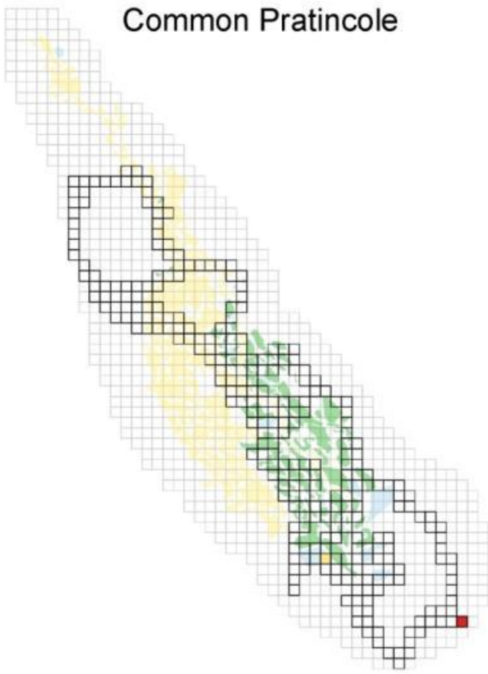
### Purple Gallinule

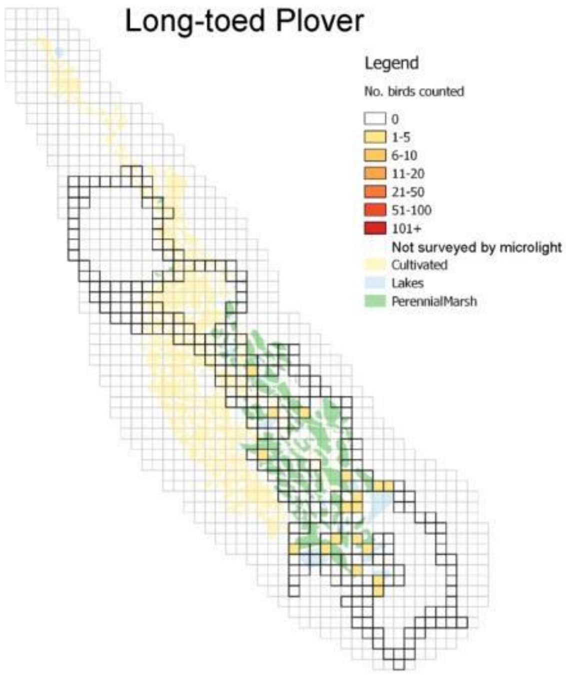


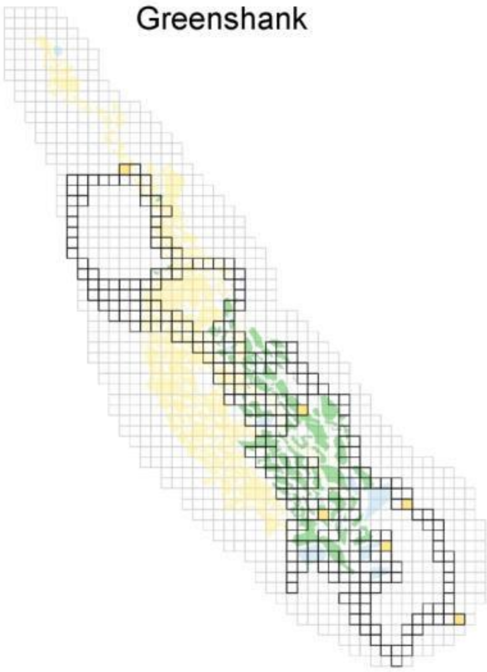

African Jacana
Legend
No. birds counted
0
1-5
6-10
11-20
21-50
51-100
101+
Not surveyed by microlight
Cultivated
Lakes
PerennialMarsh

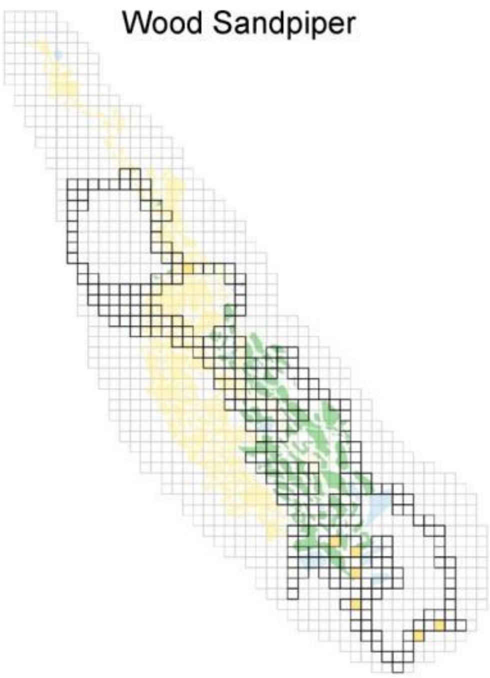

Black-winged Stilt

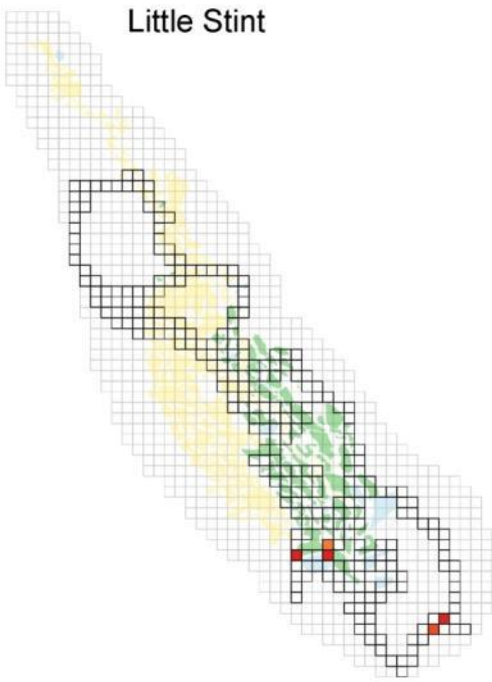

Avocet

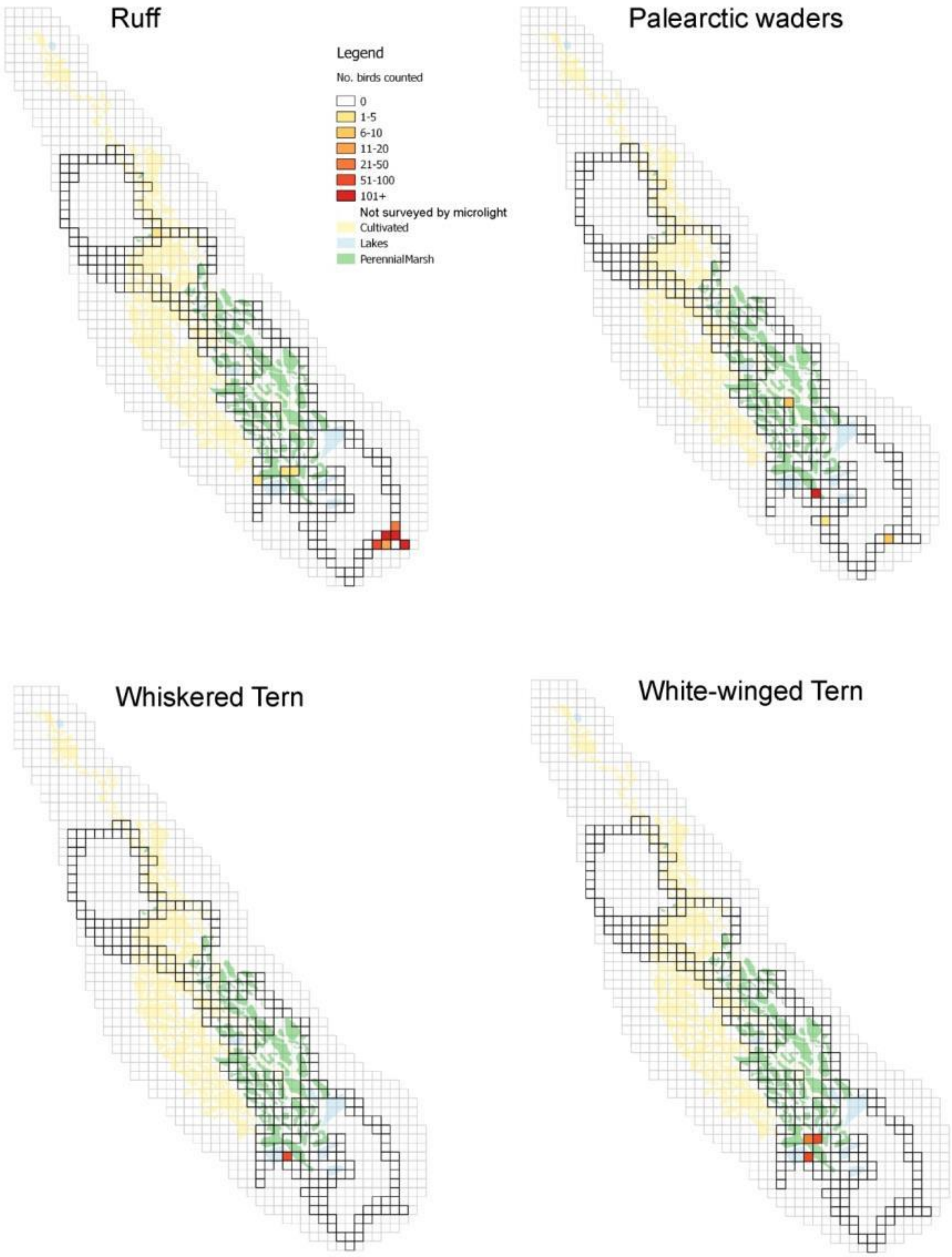

Common Pratincole


Long-toed Plover
Legend
No. birds counted
0
1-5
6-10
11-20
21-50
51-100
101+
Not surveyed by microlight
Cultivated
Lakes
PerennialMarsh

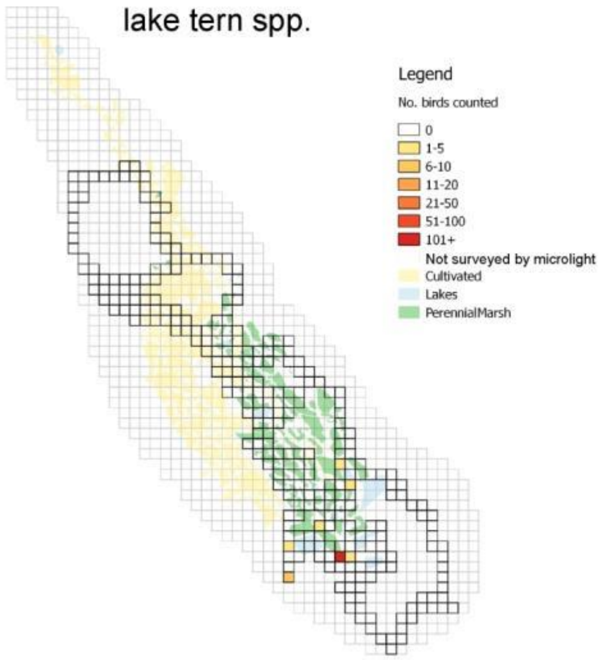

Greenshank

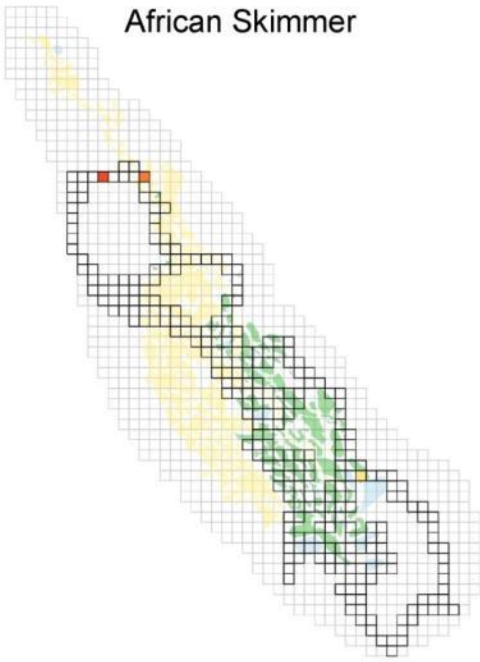

Wood Sandpiper

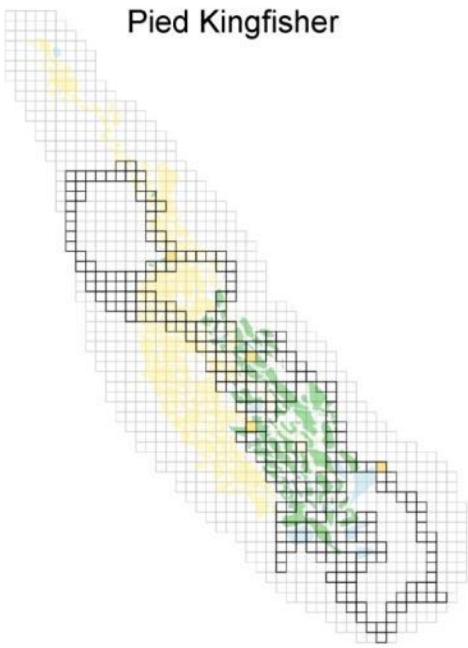

Little Stint



Ruff
Legend
No. birds counted
0
1-5
6-10
11-20
21-50
51-100
101+
Not surveyed by microlight
Cultivated
Lakes
PerennialMarsh
Palearctic waders
Whiskered Tern
White-winged Tern


lake tern spp.
Legend
No. birds counted
0
1-5
6-10
11-20
21-50
51-100
101+
Not surveyed by microlight
Cultivated
Lakes
PerennialMarsh


African Skimmer


Pied Kingfisher

# C: Waterbird counts at the 15 viewpoints (V1-V15) at the lagoons of the lower Elephant Marsh

**The 7046 waterbirds counted at each of the 15 viewpoints (V1-V15) at the lagoons of the lower Elephant Marsh surveyed during 9, 11 and 14 March 2016. See Figure 8-10 for the locations of these viewpoints.**

| Species | V1 | V2 | V3 | V4 | V5 | V6 | V7 | V8 | V9 | V10 | V11 | V12 | V13 | V14 | V15 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| White-breasted Cormorant | | | | 1 | | | | | | | | | | 12 | | **13** |
| Reed Cormorant | 250 | 49 | 96 | 14 | 43 | 4 | 50 | 4 | | 6 | 1 | 9 | 7 | | | **533** |
| African Darter | 5 | | 2 | 3 | 4 | 1 | 1 | 1 | | | | 11 | 2 | | | **30** |
| Pink-backed Pelican | 14 | 8 | 1 | 1 | 1 | | | | | | | | | 16 | | **41** |
| Little Bittern | | | | | | | 2 | | | | | | | | | **2** |
| Common Squacco Heron | 26 | 26 | 70 | 31 | 20 | 24 | 34 | 9 | 1 | 1 | 2 | 1 | 3 | 5 | | **253** |
| Cattle Egret | 31 | | | | 5 | 35 | | | 1 | | | | | | | **72** |
| Black Egret | 50 | 15 | | 4 | | 3 | | | | | | | | | | **72** |
| Little Egret | 3 | 17 | 2 | 4 | 2 | 7 | | | 1 | | | | | | | **36** |
| Yellow-billed Egret | | 4 | 3 | 3 | 5 | | 1 | | | | | | | | | **16** |
| Great White Egret | 12 | 3 | 1 | 1 | 1 | 3 | 4 | | | 1 | | | 1 | | 2 | **29** |
| Purple Heron | 2 | 1 | 8 | 1 | 1 | 4 | 7 | 4 | | 10 | 1 | | 6 | 6 | 5 | **56** |
| Grey Heron | 2 | 1 | | 1 | 2 | 4 | | | 2 | | 2 | | 2 | | 1 | **17** |
| Goliath Heron | | | | | | 1 | | | 1 | | | | | | | **2** |
| Hamerkop | 1 | | | | | | | | | | | | | | | **1** |
| Yellow-billed Stork | | | | | | 1 | | | | | | | | 8 | | **9** |
| Openbill Stork | 206 | 108 | 293 | 112 | 159 | 590 | 156 | 26 | 9 | 62 | 48 | 8 | 90 | 526 | 80 | **2473** |
| Sacred Ibis | | 3 | | | 1 | 3 | | | | | | | | 1 | | **8** |
| Glossy Ibis | 2 | | 3 | 2 | 3 | | 3 | | | | | | | | | **13** |
| Fulvous Tree Duck | 4 | | | | | | 30 | | | | | | | 4 | | **38** |
| White-faced Tree Duck | | 5 | 2 | 14 | 26 | 25 | 40 | | 40 | | | | | 12 | | **164** |
| Spur-winged Goose | | | | | | 8 | | | | | | | 5 | 47 | | **60** |
| Hottentot Teal | 1 | | | | | | | | | | | | | | | **1** |
| African Fish Eagle | 1 | | 1 | | 1 | 3 | 2 | | | 2 | 2 | | | | 1 | **13** |
| African Marsh Harrier | | 1 | 1 | | 1 | | | | | | | | | | | **3** |

| Species | V1 | V2 | V3 | V4 | V5 | V6 | V7 | V8 | V9 | V10 | V11 | V12 | V13 | V14 | V15 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Osprey | | 1 | | | | | | | | | | | | | | **1** |
| Black Crake | 3 | 2 | | 2 | 1 | 1 | 1 | 2 | | | | 1 | | | 1 | **14** |
| Purple Gallinule | 9 | 1 | 2 | | 3 | 6 | 2 | | | 7 | 9 | 3 | | | 2 | **44** |
| Common Moorhen | 3 | | | | | | | | | | | | | | | **3** |
| African Jacana | 273 | 89 | 485 | 94 | 73 | 83 | 134 | 7 | 1 | 40 | 17 | 1 | 23 | 11 | 12 | **1343** |
| Lesser Jacana | | 10 | 21 | | | | | | | | | | | | | **31** |
| Painted Snipe | 1 | | | | | | | | | | | | | | | **1** |
| Black-winged Stilt | 3 | | 6 | | | 2 | | | | | | | | 8 | | **19** |
| Common Pratincole | 30 | | | | | | | | | | | | | 20 | | **50** |
| Ringed Plover | | | | | | | | | | | | | | 1 | | **1** |
| Kittlitz's Plover | | | | | | | | | | | | | | 1 | | **1** |
| Three-banded Plover | 2 | | | | | | | | | | | | | | | **2** |
| Long-toed Plover | 14 | 17 | 24 | 8 | 12 | | 11 | | | | | | | | | **86** |
| Black-tailed Godwit | | | | | | | | | | | | | | 1 | | **1** |
| Marsh Sandpiper | 1 | | | | | | | | | | | | | | | **1** |
| Greenshank | 1 | | | | | | | | | | | | | 2 | | **3** |
| Wood Sandpiper | 4 | 2 | 16 | 6 | 2 | | | | | | | | | 21 | | **51** |
| Common Sandpiper | 13 | | | | | | | | | | | | | | | **13** |
| Little Stint | | | 417 | | | | | | | | | | | 50 | | **467** |
| Curlew Sandpiper | | | | | | | | | | | | | | 200 | | **200** |
| Ruff | 6 | | | | | | | | | | | | | 8 | | **14** |
| Grey-headed Gull | 2 | 2 | | | | | | | | | | | | 4 | | **8** |
| Whiskered Tern | 41 | 30 | 67 | 5 | 20 | 10 | 20 | | | 29 | | 20 | | | | **242** |
| White-winged Tern | 138 | 10 | 173 | 5 | 20 | 40 | 10 | | | 15 | | 20 | | | | **431** |
| African Skimmer | 2 | | | | | | | | | | | | | | | **2** |
| Malachite Kingfisher | 2 | | | | | | | | 1 | | | | 1 | | | **4** |
| Pied Kingfisher | 30 | 9 | 8 | | 1 | | 5 | 2 | | 1 | | | | 2 | | **58** |

## D: African Waterbird Census 1991 - 1999

**Results of the African Waterbird Census waterbird counts at Elephant Marsh for the period June – July 1991 to August 1999.**

| Common name | Scientific name | Jun-Jul 91 | 19 Jan 92 | 25-26 Jan 92 | Aug 92 | Jan 93 | Aug 93 | Jul 95 | Aug 95 | 12 Jun 97 | 29 Jun 97 | Jun 98 | Aug 99 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Little Grebe | *Tachybaptus ruficollis* | 1 | 21 | 21 | | | | | | | | 1 | |
| White-breasted Cormorant | *Phalacrocorax carbo* | 3 | 1 | 2 | 3 | | 8 | 6 | | | | 8 | 6 |
| Reed Cormorant | *Phalacrocorax africanus* | 129 | 43 | 23 | 111 | 5 | 4 | 20 | 22 | 42 | | 51 | 273 |
| African Darter | *Anhinga rufa* | 7 | 8 | 7 | 3 | | | 7 | | | | | 3 |
| White Pelican | *Pelecanus onocrotalus* | | 15 | | | 1 | 4 | | | | | | |
| Pink-backed Pelican | *Pelecanus rufescens* | 4 | 12 | 12 | 2 | 4 | 2 | 4 | | 2 | | 19 | 2 |
| Little Bittern | *Ixobrychus minutus* | | | | | | | | | 1 | | | |
| Dwarf Bittern | *Ixobrychus sturmii* | | | | | | | | | | | | |
| Black-crowned Night Heron | *Nycticorax nycticorax* | 1 | 1 | 1 | 40 | | | 1 | | | 7 | | |
| White-backed Night Heron | *Gorsachius leuconotus* | | | | | 1 | | | | | | | |
| Common Squacco Heron | *Ardeola ralloides* | 39 | 127 | 300 | 7 | 7 | 22 | 5 | 10 | 22 | 1 | 16 | 51 |
| Rufous-bellied Heron | *Aredeola rufiventris* | | | | | | | | | | | | |
| Cattle Egret | *Bubulcus ibis* | 30 | 107 | 100 | 17 | 40 | 30 | 38 | 150 | 332 | 1379 | 258 | 261 |
| Green-backed Heron | *Butorides striata* | 5 | | | | | | 2 | | | 2 | | |
| Slaty Egret | *Egretta vinaceigula* | | | | | | | | | | | | |
| Black Egret | *Egretta ardesiaca* | 11 | 2 | | | 5 | | | | 24 | | | 9 |
| Little Egret | *Egretta garzetta* | 7 | 3 | | 34 | | 1 | | | 6 | | 3 | 8 |
| Yellow-billed Egret | *Egretta intermedia* | 3 | | | 4 | | 5 | | | 7 | | 2 | 2 |
| Great White Egret | *Egretta alba* | 6 | 6 | 4 | 14 | 5 | 8 | | 3 | 23 | | 6 | 9 |
| Purple Heron | *Ardea purpurea* | 5 | 21 | 21 | | 8 | | | 1 | 12 | | 14 | 14 |
| Grey Heron | *Ardea cinerea* | 4 | 1 | 1 | 18 | 3 | 3 | 9 | | 13 | 4 | 15 | 10 |
| Black-headed Heron | *Ardea melanocephala* | 4 | 1 | 1 | 2 | 8 | | | 3 | 62 | 9 | 11 | 11 |
| Goliath Heron | *Ardea goliath* | 6 | 1 | 2 | | | 1 | 2 | 1 | 1 | | | 1 |
| Hamerkop | *Scopus umbretta* | | | | 2 | | | 7 | | | | | 3 |

| Common name | Scientific name | Jun-Jul 91 | 19 Jan 92 | 25-26 Jan 92 | Aug 92 | Jan 93 | Aug 93 | Jul 95 | Aug 95 | 12 Jun 97 | 29 Jun 97 | Jun 98 | Aug 99 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yellow-billed Stork | *Mycteria ibis* | 3 | | | 3 | | 19 | | | 7 | 10 | 32 | 28 |
| Openbill Stork | *Anastomus lamelligerus* | 77 | 270 | 200 | 18 | | 25 | 8 | 17 | 88 | 13 | 99 | 137 |
| Black Stork | *Ciconia nigra* | | | | | | | | | | | | |
| Woolly-necked Stork | *Ciconia episcopus* | | | | 1 | | | | | | | | |
| Saddle-billed Stork | *Ephippiorhynchus senegalensis* | | | | | | | 2 | | | | | |
| Marabou Stork | *Leptoptilos crumeniferus* | | | | 7 | | | 1 | | | | 4 | |
| Sacred Ibis | *Threskiornis aethiopicus* | 14 | 8 | 7 | | 1 | 10 | | 9 | 11 | 1 | | 4 |
| Glossy Ibis | *Plegadis falcinellus* | 24 | 102 | 102 | | 3 | 5 | | 13 | 24 | | | 29 |
| Hadeda Ibis | *Bostrychia hagedash* | 6 | | | | | 3 | 3 | | | | | |
| African Spoonbill | *Platalea alba* | 2 | | | | | | | | 1 | | | 9 |
| Greater Flamingo | *Phoenicopterus ruber* | | | | | | | | | | | 2 | |
| Fulvous Tree Duck | *Dendrocygna bicolor* | 64 | 5 | 5 | | 48 | 700 | 3 | | 12 | | 45 | 149 |
| White-faced Tree Duck | *Dendrocygna viduata* | 356 | 12 | 42 | | 10 | 97 | 16 | | | 84 | 27 | 88 |
| White-backed Duck | *Thalassornis leuconotus* | 6 | 4 | | | | | 2 | | | | | |
| Egyptian Goose | *Alopochen aegyptiaca* | 1 | | | | | 7 | 3 | | | | | |
| Spur-winged Goose | *Plectropterus gambensis* | 59 | 35 | 30 | | 12 | 22 | 5 | 6 | 5 | | | 25 |
| Knob-billed Duck | *Sarkidiornis melanotos* | 105 | 3 | | | 3 | 27 | | | 4 | | | 10 |
| Pygmy Goose | *Nettapus auritus* | 8 | 6 | 6 | | | 4 | | 4 | 2 | | | |
| Red-billed Teal | *Anas erythrorhyncha* | | | | | | | 2 | | | 10 | | |
| Hottentot Teal | *Anas hottentota* | 2 | | | | | 8 | | | | | | |
| Southern Pochard | *Anas hottentota* | | | | | | | | 20 | | | | |
| African Fish Eagle | *Haliaeetus vocifer* | 8 | 4 | | 3 | 1 | 4 | 4 | | | | 6 | 6 |
| African Marsh Harrier | *Circus ranivorus* | 2 | 2 | 2 | | | | | 1 | 4 | 1 | 1 | 2 |
| Osprey | *Pandion haliaetus* | | | | | | | 1 | | | | | |
| African Water Rail | *Rallus caerulescens* | | | | | | | | | | | | |
| Corncrake | *Crex crex* | | | | | | | | | | | | |
| African Crake | *Crecopsis egregia* | | | | | | | 3 | | | | | |

| **Common name** | **Scientific name** | **Jun-Jul 91** | **19 Jan 92** | **25-26 Jan 92** | **Aug 92** | **Jan 93** | **Aug 93** | **Jul 95** | **Aug 95** | **12 Jun 97** | **29 Jun 97** | **Jun 98** | **Aug 99** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Black Crake | *Amaurornis flavirostra* | 5 | 3 | 2 | | | 2 | | 1 | | | 4 | 8 |
| Purple Gallinule | *Porphyrio porphyrio* | 18 | 27 | 22 | | 35 | 270 | 1 | | | | 4 | |
| Lesser Gallinule | *Porphyrio alleni* | | | | | 3 | 1 | | | 2 | | | |
| Common Moorhen | *Gallinula chloropus* | | 15 | 10 | | | | | 2 | | | | |
| Lesser Moorhen | *Gallinula angulata* | | | | | | | 1 | | | | | |
| African Finfoot | *Podica senegalensis* | | | | | | | | | | | | |
| African Jacana | *Actophilornis africanus* | 56 | 210 | 400 | 14 | 42 | | 5 | 65 | 55 | | 310 | 169 |
| Lesser Jacana | *Microparra capensis* | 6 | 15 | 20 | | 34 | | 2 | 1 | | | | 5 |
| Painted Snipe | *Rostratula benghalensis* | | | | | | | | | | | | |
| Black-winged Stilt | *Himantopus himantopus* | 3 | | | | | 3 | 2 | 2 | 3 | | 11 | 8 |
| Avocet | *Recurvirostra avosetta* | | | | | | | | 1 | | | | |
| Water Dikkop | *Burhinus vermiculatus* | 4 | | | | | | 3 | | | | | |
| Spotted Dikkop | *Burhinus capensis* | | | | | | | | | | | | |
| Common Pratincole | *Glareola pratincola* | 14 | 420 | 90 | | | 30 | | 5 | 255 | | 15 | |
| Ringed Plover | *Charadrius hiaticula* | | | | 1 | | | | | 5 | | | |
| Kittlitz's Plover | *Charadrius pecuarius* | | | | 21 | | | 3 | | 17 | | 2 | |
| Three-banded Plover | *Charadrius tricollaris* | | | | | | | 7 | | | | | |
| White-fronted Sand Plover | *Charadrius marginatus* | 2 | | | | | | 3 | | | | | |
| Senegal Wattled Plover | *Vanellus senegallus* | 1 | | | | | | 6 | | | | | |
| White-crowned Plover | *Vanellus albiceps* | | | | | | | | | | 1 | | |
| Blacksmith Plover | *Vanellus armatus* | | 2 | | | | | 1 | | 6 | | 2 | 2 |
| Spur-winged Plover | *Vanellus asspinosus* | | | | | | | | | | | | |
| Lesser Black-winged Plover | *Vanellus lugubris* | 2 | | | | | | | | | | | |
| Long-toed Plover | *Vanellus crassirostris* | 1 | 8 | | | 3 | 7 | | 2 | 47 | | 3 | 21 |
| Ethiopian Snipe | *Gallinago nigripennis* | | | | | | | | | 1 | | | |
| Great Snipe | *Gallinago media* | | | | | | | | | | | | |
| Common Redshank | *Tringa totatus* | | 5 | | | | | | | | | | |

| **Common name** | **Scientific name** | **Jun-Jul 91** | **19 Jan 92** | **25-26 Jan 92** | **Aug 92** | **Jan 93** | **Aug 93** | **Jul 95** | **Aug 95** | **12 Jun 97** | **29 Jun 97** | **Jun 98** | **Aug 99** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Marsh Sandpiper | *Tringa stagnatilis* | | 12 | 26 | 1 | | | | | 1 | | | |
| Greenshank | *Tringa nebularia* | 2 | 2 | 32 | 2 | | | 2 | | 2 | 3 | | 1 |
| Wood Sandpiper | *Tringa glareola* | | 1 | | 13 | 2 | | 4 | | 2 | | | |
| Common Sandpiper | *Actitis hypoleucos* | 1 | 12 | | 1 | | | 4 | | 1 | | | |
| Little Stint | *Calidris minuta* | | | | 11 | | | 6 | | | | | |
| Curlew Sandpiper | *Calidris ferruginea* | | | | 8 | | | | | | | | |
| Ruff | *Philomachus pugnax* | | 6 | | 4 | | | 1 | | | | | |
| Grey-headed Gull | *Larus cirrocephalus* | 14 | | | | | 3 | 2 | | | | | 3 |
| Whiskered Tern | *Chlidonias hybrida* | | | | | 2 | 1 | | 6 | 1 | | 6 | 6 |
| White-winged Tern | *Chlidonias leucopterus* | 4 | 206 | | 21 | 100 | 6 | | | 58 | | | |
| African Skimmer | *Rynchops flavirostris* | | | | | | | | | | | 20 | |
| Pel's Fishing Owl | *Scotopelia peli* | | | | | | | | | | | | |
| Marsh Owl | *Asio capensis* | | | | | | 1 | | | | | | |
| Malachite Kingfisher | *Alcedo cristata* | | | | | | | | | | | | |
| Giant Kingfisher | *Megaceryle maxima* | | | | | | | | | | | | |
| Pied Kingfisher | *Ceryle rudis* | | | | | | | | | | | | |
| African Pied Wagtail | *Motacilla aguimp* | | | | | | | | | | | | |
| **Totals** | | **1134** | **1765** | **1491** | **386** | **386** | **1343** | **207** | **345** | **1161** | **1525** | **997** | **1373** |
| **Number of species** | | **48** | **42** | **29** | **29** | **26** | **34** | **41** | **23** | **38** | **14** | **30** | **35** |

# E: African Waterbird Census 2007 - 2016

**Results of the African Waterbird Census waterbird counts at Elephant Marsh for the period December 2007 to January 2016.**

| **Common name** | **Scientific name** | **Dec 07** | **Aug 08** | **Jan 09** | **Dec 09** | **Jul 11** | **Aug 11** | **Mar 12** | **Jul 12** | **Sep 12** | **Feb 14** | **Jan 15** | **Jan 16** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Little Grebe | *Tachybaptus ruficollis* | | | | | | | | | | | | 95 |
| White-breasted Cormorant | *Phalacrocorax carbo* | | 27 | 3 | 4 | 22 | 4 | | | 1 | | 4 | 4 |
| Reed Cormorant | *Phalacrocorax africanus* | 72 | 20 | 2 | 3 | 12 | 2 | 9 | 24 | 35 | | 150 | 1000 |
| African Darter | *Anhinga rufa* | | 1 | | | | | | | 6 | 2 | | 2 |
| White Pelican | *Pelecanus onocrotalus* | | 6 | | 8 | 44 | | | | 3 | | | |
| Pink-backed Pelican | *Pelecanus rufescens* | 13 | | | | | | | 49 | 27 | | 150 | 300 |
| Little Bittern | *Ixobrychus minutus* | | | | 2 | 1 | | | | | 2 | 6 | 8 |
| Dwarf Bittern | *Ixobrychus sturmii* | | | 1 | 1 | | | | | | | | |
| Black-crowned Night Heron | *Nycticorax nycticorax* | | 2 | 5 | 4 | 8 | | | | 2 | 37 | 2 | |
| White-backed Night Heron | *Gorsachius leuconotus* | | | | | | | | | | 17 | | |
| Common Squacco Heron | *Ardeola ralloides* | 128 | 71 | 17 | 33 | 4 | 8 | 12 | 19 | 35 | 19 | 2 | 120 |
| Rufous-bellied Heron | *Aredeola rufiventris* | | | | | | | 1 | | | | | |
| Cattle Egret | *Bubulcus ibis* | 8 | 54 | 6 | 25 | 22 | 16 | | 31 | 80 | 277 | 400 | 600 |
| Green-backed Heron | *Butorides striata* | | 11 | 5 | 3 | 17 | | 5 | | 5 | 13 | 1 | 8 |
| Slaty Egret | *Egretta vinaceigula* | | | | 4 | | | | | | | | |
| Black Egret | *Egretta ardesiaca* | 59 | | 1 | 1 | 7 | 1 | 1 | 1 | | | 100 | 800 |
| Little Egret | *Egretta garzetta* | 15 | 35 | 55 | 15 | 200 | 4 | 9 | 7 | 20 | 1123 | 24 | 117 |
| Yellow-billed Egret | *Egretta intermedia* | 1 | 15 | 116 | 12 | 238 | 8 | 6 | 4 | 2 | 223 | 10 | 200 |
| Great White Egret | *Egretta alba* | 28 | 2 | 7 | 5 | 3 | 1 | 1 | 5 | 10 | 12 | | |
| Purple Heron | *Ardea purpurea* | 19 | 22 | | 4 | 7 | | 4 | 17 | 20 | 12 | 1 | 250 |
| Grey Heron | *Ardea cinerea* | 5 | 10 | 10 | | 5 | | | 9 | 1 | 5 | 7 | 18 |
| Black-headed Heron | *Ardea melanocephala* | 4 | 8 | 5 | 3 | 3 | 3 | 1 | 3 | | 18 | | |
| Goliath Heron | *Ardea goliath* | 2 | 6 | | | 4 | | 1 | 1 | 1 | 4 | 2 | 2 |
| Hamerkop | *Scopus umbretta* | | 1 | 1 | 1 | 5 | | | | | | 2 | 35 |

| Common name | Scientific name | Dec 07 | Aug 08 | Jan 09 | Dec 09 | Jul 11 | Aug 11 | Mar 12 | Jul 12 | Sep 12 | Feb 14 | Jan 15 | Jan 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yellow-billed Stork | *Mycteria ibis* | | | 17 | 2 | 6 | | 5 | 2 | 14 | 5 | | 18 |
| Openbill Stork | *Anastomus lamelligerus* | 47 | 40 | 18 | 20 | 22 | 4 | 23 | 100 | 70 | 22 | 200 | 600 |
| Black Stork | *Ciconia nigra* | | | | | 4 | | | | | | | |
| Woolly-necked Stork | *Ciconia episcopus* | | | | 3 | 3 | | | | | 17 | | |
| Saddle-billed Stork | *Ephippiorhynchus senegalensis* | | | | | | | | | | | | |
| Marabou Stork | *Leptoptilos crumeniferus* | | 4 | | 15 | 8 | 4 | | 6 | | 8 | | |
| Sacred Ibis | *Threskiornis aethiopicus* | 1 | | 4 | | 4 | | 5 | 3 | 1 | 121 | 2 | 4 |
| Glossy Ibis | *Plegadis falcinellus* | 6 | | 4 | 3 | 8 | 5 | | 25 | 90 | | 3 | 700 |
| Hadeda Ibis | *Bostrychia hagedash* | | | | | | | | | | | | |
| African Spoonbill | *Platalea alba* | | | | | 20 | | | 5 | | 2 | 18 | 6 |
| Greater Flamingo | *Phoenicopterus ruber* | | | | | | | | | | | | |
| Fulvous Tree Duck | *Dendrocygna bicolor* | | | | | 8 | | | 45 | 80 | | | 400 |
| White-faced Tree Duck | *Dendrocygna viduata* | 1 | 781 | 6 | 15 | 444 | 10 | 31 | 100 | 700 | 2132 | 200 | 2000 |
| White-backed Duck | *Thalassornis leuconotus* | 29 | | | | | | | | | | | |
| Egyptian Goose | *Alopochen aegyptiaca* | | | | | 4 | | | | 1 | 4 | | |
| Spur-winged Goose | *Plectropterus gambensis* | 31 | 33 | | 15 | 22 | 4 | 4 | 12 | 28 | 78 | 24 | 24 |
| Knob-billed Duck | *Sarkidiornis melanotos* | | | | 6 | 20 | | | 14 | | | 4 | 2 |
| Pygmy Goose | *Nettapus auritus* | | | | | | | | | | | | |
| Red-billed Teal | *Anas erythrorhyncha* | | | | | | | | 8 | | | | 6 |
| Hottentot Teal | *Anas hottentota* | | | | | | | | 28 | | | | |
| Southern Pochard | *Anas hottentota* | | | | | | | | | | | | |
| African Fish Eagle | *Haliaeetus vocifer* | | 2 | 2 | 3 | 2 | 1 | 2 | 1 | 4 | | 4 | |
| African Marsh Harrier | *Circus ranivorus* | | 8 | | 2 | 4 | 2 | 2 | 2 | 1 | 4 | 1 | |
| Osprey | *Pandion haliaetus* | | 1 | | | | | | | | | | |
| African Water Rail | *Rallus caerulescens* | | | | | | | | 4 | | | 1 | 2 |
| Corncrake | *Crex crex* | | | | | | | 1 | | | | | |
| African Crake | *Crecopsis egregia* | | | 3 | 1 | 15 | 4 | | 19 | | 4 | | |

| Common name | Scientific name | Dec 07 | Aug 08 | Jan 09 | Dec 09 | Jul 11 | Aug 11 | Mar 12 | Jul 12 | Sep 12 | Feb 14 | Jan 15 | Jan 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Black Crake | *Amaurornis flavirostra* | 3 | 43 | | 15 | | | | 78 | | | 16 | 35 |
| Purple Gallinule | *Porphyrio porphyrio* | 1 | | | | | | | | | | 8 | 20 |
| Lesser Gallinule | *Porphyrio alleni* | | | | 5 | 2 | 2 | | | 2 | | 6 | |
| Common Moorhen | *Gallinula chloropus* | | | | 5 | | 1 | | 7 | | | 2 | 100 |
| Lesser Moorhen | *Gallinula angulata* | | | | 1 | | | | | | 4 | 18 | 2 |
| African Finfoot | *Podica senegalensis* | | 1 | | | | | | | | | | |
| African Jacana | *Actophilornis africanus* | 77 | 124 | 16 | 2 | 23 | 4 | 5 | 39 | | 22 | 100 | 200 |
| Lesser Jacana | *Microparra capensis* | 1 | | | | | | | 3 | | | | |
| Painted Snipe | *Rostratula benghalensis* | 1 | | | | | | | | 5 | 2 | | |
| Black-winged Stilt | *Himantopus himantopus* | | | 11 | | | 1 | | 48 | 20 | | | 300 |
| Avocet | *Recurvirostra avosetta* | | | | | | | | | | | | |
| Water Dikkop | *Burhinus vermiculatus* | | 2 | | | 4 | | | 86 | | | | 25 |
| Spotted Dikkop | *Burhinus capensis* | | | | | | | | | | 3 | | |
| Common Pratincole | *Glareola pratincola* | | 2 | | 2 | 22 | | | 100 | | 5 | 400 | 2000 |
| Ringed Plover | *Charadrius hiaticula* | | | | | | | | | 15 | | 6 | |
| Kittlitz's Plover | *Charadrius pecuarius* | | | 4 | 4 | | | | 100 | 60 | | 200 | 120 |
| Three-banded Plover | *Charadrius tricollaris* | | | 11 | 15 | 3 | 2 | | 20 | | | 7 | 3 |
| White-fronted Sand Plover | *Charadrius marginatus* | | | | | | | | | | | | |
| Senegal Wattled Plover | *Vanellus senegallus* | | | | | | | | | | | | |
| White-crowned Plover | *Vanellus albiceps* | | 5 | | | | | | | | | | |
| Blacksmith Plover | *Vanellus armatus* | | | | | 10 | | 1 | | | 11 | | |
| Spur-winged Plover | *Vanellus asspinosus* | | | | | | | | | 2 | | | 4 |
| Lesser Black-winged Plover | *Vanellus lugubris* | | | | 2 | | | | | | | | |
| Long-toed Plover | *Vanellus crassirostris* | 3 | | | 4 | | | | 25 | 8 | | | 200 |
| Ethiopian Snipe | *Gallinago nigripennis* | | | | | | | | | | | | 1 |
| Great Snipe | *Gallinago media* | | | | | | | | | | 17 | | |
| Common Redshank | *Tringa totatus* | | | 4 | | | | | | | 15 | | |

| **Common name** | **Scientific name** | **Dec 07** | **Aug 08** | **Jan 09** | **Dec 09** | **Jul 11** | **Aug 11** | **Mar 12** | **Jul 12** | **Sep 12** | **Feb 14** | **Jan 15** | **Jan 16** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Marsh Sandpiper | *Tringa stagnatilis* | | 3 | 7 | 3 | 2 | 2 | | 2 | | 7 | 2 | |
| Greenshank | *Tringa nebularia* | | | 3 | 3 | 2 | 2 | | 3 | 10 | 14 | 8 | 18 |
| Wood Sandpiper | *Tringa glareola* | 2 | | 9 | 4 | | 1 | | | 35 | 12 | 10 | 33 |
| Common Sandpiper | *Actitis hypoleucos* | | | 12 | 4 | 42 | 3 | | | 5 | 12 | 18 | 18 |
| Little Stint | *Calidris minuta* | | | | | | | | | 50 | | 300 | 400 |
| Curlew Sandpiper | *Calidris ferruginea* | | | | | | | | | 25 | 4 | | |
| Ruff | *Philomachus pugnax* | | | 77 | | | 6 | | | 25 | | | |
| Grey-headed Gull | *Larus cirrocephalus* | | | | | | | | 100 | 30 | | | 4 |
| Whiskered Tern | *Chlidonias hybrida* | 17 | | | | | | | 100 | 60 | | | 3000 |
| White-winged Tern | *Chlidonias leucopterus* | 55 | | | 4 | 4 | 4 | | | 60 | | | |
| African Skimmer | *Rynchops flavirostris* | | 332 | | 77 | 283 | | 300 | | 360 | | 600 | 28 |
| Pel's Fishing Owl | *Scotopelia peli* | | | | | | | | | | | | |
| Marsh Owl | *Asio capensis* | | | | | | | | | | 2 | | |
| Malachite Kingfisher | *Alcedo cristata* | | | | | | | | | | | | 28 |
| Giant Kingfisher | *Megaceryle maxima* | | | | | | | | | | | | 2 |
| Pied Kingfisher | *Ceryle rudis* | | | | | | | | | | | | 300 |
| African Pied Wagtail | *Motacilla aguimp* | | | | | | | | | | 5 | | |
| **Totals** | | **629** | **1672** | **442** | **359** | **1593** | **109** | **429** | **1255** | **2009** | **4296** | **3019** | **14162** |
| **Number of species** | | **27** | **31** | **31** | **43** | **44** | **28** | **22** | **42** | **42** | **39** | **40** | **50** |

# F: Population thresholds for the waterbird species

**1% population thresholds for the waterbird species (as defined by the Ramsar Convention) that have been recorded at Elephant Marsh or at least in the lower Shire River area, as taken from Wetlands International (2016).**

| Species | Relevant population | 1% threshold |
|---|---|---|
| Little Grebe | Sub-Saharan Africa | 10 000 |
| White-breasted Cormorant | Central & Eastern Africa | 3200 |
| Reed Cormorant | S & E Africa | 10 000 |
| African Darter | S & E Africa | 1000 |
| White Pelican | Southern Africa | 300 |
| Pink-backed Pelican | Tropical Africa & SW Arabia | 710 |
| Little Bittern | *minutus*, W Europe NW Africa/Sub-Saharan Africa | 150 |
| | *minutus*, C & E Europe Black Sea & E Mediterranean/Sub-Saharan Africa | 1900 |
| | *minutus*, West and South-west Asia/Sub-Saharan Africa | 1000 |
| | *payesii*, Sub-Saharan Africa | 1000 |
| Dwarf Bittern | Sub-Saharan Africa | 1000 |
| Black-crowned Night Heron | *nycticorax*, Sub-Saharan Africa & Madagascar | 10 000 |
| White-backed Night Heron | Africa | 1000 |
| Madagascar Squacco Heron | Madagascar & Albara/Central & Eastern Africa | 35 |
| Common Squacco Heron | *paludivaga* | 4200 |
| Rufous-bellied Heron | Tropical Eastern & Southern Africa | 1000 |
| Cattle Egret | Southern Africa/Tropical Africa | 10 000/20 000 |
| Green-backed Heron | *atricapilla* | 10 000 |
| Black Egret | Sub-Saharan Africa | 1000 |
| Little Egret | *garzetta*, Sub-Saharan Africa | 3200 |
| Yellow-billed Egret | *brachyrhncha*, Sub-Saharan Africa | 1000 |
| Great White Egret | Sub-Saharan Africa & Madagascar | 2200 |
| Purple Heron | Tropical Africa | 870 |
| Grey Heron | Sub-Saharan Africa | 10 000 |
| Black-headed Heron | Sub-Saharan Africa | 2200 |
| Goliath Heron | Sub-Saharan Africa | 1000 |
| Hamerkop | *umbretta* | 10 000 |
| Yellow-billed Stork | Sub-Saharan Africa (excluding Madsagascar) | 870 |
| Openbill Stork | *lamelligerus*, Sub-Saharan Africa | 3900 |
| Black Stork | Southern Africa | 25 |
| Abdim's Stork | Sub-Saharan Africa & SW Arabia | 4200 |
| Woolly-necked Stork | *microscelis*, Sub-Saharan Africa | 1000 |
| White Stork | W Europe & NW Africa/Sub-Saharan Africa | 1600 |
| | Central & Eastern Europe/Sub-Saharan Africa | 5200 |
| Saddle-billed Stork | Africa | 50 |
| Marabou Stork | Sub-Saharan Africa | 3200 |
| Sacred Ibis | *aethiopicus*, Sub-Saharan Africa | 3000 |
| Glossy Ibis | *falcinellus*, Sub-Saharan Africa (bre) | 20 000 |
| Hadeda Ibis | *brevirostris* | 1000 |
| African Spoonbill | Sub-Saharan Africa | 1000 |

| Species | Relevant population | 1% threshold |
|---|---|---|
| Greater Flamingo | Eastern Africa/Southern Africa (to Madagascar) | 350/750 |
| Lesser Flamingo | Eastern Africa/Southern Africa (to Madagascar) | 19 400/600 |
| Fulvous Tree Duck | Eastern & Southern Africa | 2300 |
| White-faced Tree Duck | Easter & Southern Africa | 10 000 |
| White-backed Duck | *leuconotus*, Eastern & Southern Africa | 250 |
| Egyptian Goose | Eastern & Southern Africa | 3200 |
| Spur-winged Goose | *gambensis*, Eastern Africa (Sudan to Zambia) | 2400 |
| Knob-billed Duck | *melanotos*, Southern & Eastern Africa | 2200 |
| Pygmy Goose | Southern & Eastern Africa | 1600 |
| African Black Duck | *sparsa* | 250 |
| Yellow-billed Duck | *undulata*, Southern Africa | 1000 |
| Red-billed Teal | Southern Africa/Eastern Africa | 7100/1700 |
| Hottentot Teal | Southern Africa | 1000 |
| Garganey | Western Siberia/SW Asia NE & Eastern Africa | 1400 |
| Southern Pochard | *brunnea*, Southern & Eastern Africa | 460 |
| African Water Rail | Southern & Eastern Africa | ? |
| Corncrake | Europe & Western Asia/Sub-Saharan Africa | 20 000 |
| African Crake | Sub-Saharan Africa | ? |
| Black Crake | Sub-Saharan Africa | 20 000 |
| Purple Gallinule | *madagascariensis*, E, C, S Africa | 10 000 |
| Lesser Gallinule | Sub-Saharan Africa | 10 000 |
| Common Moorhen | *meridionalis* | 10 000 |
| Lesser Moorhen | Sub-Saharan Africa | 10 000 |
| Red-knobbed Coot | Sub-Saharan Africa | 10 000 |
| Wattled Crane | Central & Southern Africa | 1 |
| Southern Crowned Crane | *gibbericeps*, Eastern Africa (Kenya to Mozambique) | 320 |
| African Finfoot | *petersii* | 1000 |
| African Jacana | Sub-Saharan Africa | 20 000 |
| Lesser Jacana | Sub-Saharan Africa | 1000 |
| Painted Snipe | *benghalensis*, Sub-Saharan Africa | 1000 |
| Black-winged Stilt | *himantopus*, Sub-Saharan Africa (excluding south)/Southern Africa (?*meridionalis*?) | 1400/210 |
| Avocet | Southern Africa/Eastern Africa | 190/1000 |
| Water Dikkop | *vermiculatus* | 1000 |
| Spotted Dikkop | *capensis* | 570 |
| Bronze-winged Courser | (*albofasciatus*) | 170 |
| Temminck's Courser | *ruvanensis* | 450 |
| Common Pratincole | *fuelleborni* | 1000 |
| Black-winged Pratincole | SE Europe & Western Asia/Southern Africa | 1700 |
| Ringed Plover | (*psammodroma*), Canada Greenland & Iceland/W & S Africa / tundrae, NE Europe & Siberia/SW Asia E & S Africa | 2800/10 000 |
| Kittlitz's Plover | *pecuarius*, Southern & Eastern Africa | 2000 |
| Three-banded Plover | *tricollaris*, Southern & Eastern Africa | 950 |
| White-fronted Sand Plover | *mechowi* or *tenellus*, Inland East & Central Africa | 120 |
| Caspian Plover | SE Europe & West Asia/E & South-central Africa | 470 |
| Pacific Golden Plover | North-central Siberia/South & SW Asia NE Africa | 710 |
| Grey Plover | *squatarola*, C & E Siberia/SW Asia Eastern & Southern Africa | 900 |

| Species | Relevant population | 1% threshold |
|---|---|---|
| Senegal Wattled Plover | *lateralis*, Eastern & South-east Africa | 1000 |
| White-crowned Plover | SE Africa | 320 |
| Blacksmith Plover | S & Africa | 10 000 |
| Spur-winged Plover | Africa | 2600 |
| Lesser Black-winged Plover | Central & Eastern Africa | 320 |
| Long-toed Plover | *leucopterus*, Zambia, Mozambique | 350 |
| Ethiopian Snipe | angolensis | 1000 |
| Great Snipe | Western Siberia & NE Europe/South-east Africa | 10 000 |
| Black-tailed Godwit | *limosa*, West-central Asia/SW Asia & Eastern Africa | 1000 |
| Bar-tailed Godwit | *taymyrensis*, Central Siberia/South & SW Asia & Eastern Africa | 1200 |
| Whimbrel | *phaeopus*, Western Siberia/Southern & Eastern Africa | 10 000 |
| Common Redshank | *ussuriensis*, Western Asia/SW Asia NE & Eastern Africa | 10 000 |
| Marsh Sandpiper | Western Asia/SW Asia Eastern & Southern Africa | 710 |
| Greenshank | Western Siberia/SW Asia E & S Africa | 10 000 |
| Green Sandpiper | Western Siberia/SW Asia NE & Eastern Africa | 20 000 |
| Wood Sandpiper | NE Europe & W Siberia/Eastern & Southern Africa | 20 000 |
| Terek Sandpiper | NE Europe & W Siberia/SW Asia/E & S Africa | 10 000 |
| Common Sandpiper | e Europe & W Siberia/Central E & s Africa | 20 000 |
| Sanderling | South-west Asia Eastern & Southern Africa | 1500 |
| Little Stint | Western Siberia/SW Asia E & S Africa | 10 000 |
| Curlew Sandpiper | Central Siberia/SW Asia E & S Africa | 4000 |
| Ruff | Northern Siberia/SW Asia E & S Africa | 20 000 |
| Lesser Black-backed Gull | *fuscus*, NE Europe/Black Sea Sw Asia & Eastern Africa | 560 |
| Grey-headed Gull | *poiocephalus*, Central & Eastern Africa | 2800 |
| Common Tern | *hirundo*, Northern & Eastern Europe (bre) | 9800 |
| Whiskered Tern | *sclateri*, Southern Africa (Malawi & Zambia to South Africa) | 85 |
| White-winged Tern | Eastern Europe & Western Asia/Africa | 30 000 |
| African Skimmer | Eastern & Southern Africa | 100 |

# Appendix 7: Mammals

## A: Mammal species of Malawi and the Elephant Marsh

**Mammals of Malawi and the Elephant Marshes (EM) (see section 9.2 for the list of references used to compile the data). Conservation and CITES statuses are also indicated. YES, present; NO, not present; ??, uncertain/presence not impossible. # (CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near threatened; LC, Least concern; DD, Data deficient; NE, Not evaluated). In the case of porcupine and large herbivores, NP (Nyala Park) and NWS (Nyasa Wildlife Sanctuary) indicate that the specific species were only found in the protected area during this study.**

| Mammal species | Historically occurred in Malawi | Historically occurred in the EM | This study: found at the EM | Today expected in the EM | IUCN Redlist and CITES status# |
|---|---|---|---|---|---|
| **Order MACROSCELIDEA** | | | | | |
| Four-toed sengi *Petrodromus tetradactylus* | YES | YES | NO | YES | LC |
| Chequered sengi *Rhynchocyon cirnei* | YES | YES | NO | ?? | NT |
| Dusky sengi *Elephantulus fuscus* | YES | YES | YES | YES | DD |
| Short-snouted sengi *Elephantulus brachyrhynchus* | YES | NO | NO | NO | LC |
| Eastern rock sengi *Elephantulus myurus* | ?? | ?? | NO | NO | LC |
| **Order TUBULIDENTATA** | | | | | |
| Aardvark *Orycteropus afer* | YES | YES | NO | ?? | LC |
| **Order HYRACOIDEA** | | | | | |
| Rock hyrax *Procavia capensis* | YES | NO | NO | NO | LC |
| Yellow-spotted rock hyrax *Heterohyrax brucei* | YES | ?? | NO | ?? | LC |
| Southern tree hyrax *Dendrohyrax arboreus* | YES | YES | NO | YES | LC |
| **Order PROBOSCIDEA** | | | | | |
| African elephant *Loxodonta africana* | YES | YES | NO | NO | VU; CITES 1 |
| **Order LAGOMORPHA** | | | | | |
| African savanna hare *Lepus microtis* | YES | YES | YES (NP & NWS) | YES | LC |
| Smith's red rock rabbit *Pronolagus rupestris* | YES | NO | NO | NO | LC |
| **Order RODENTIA** | | | | | |
| **Family BATHYERGIDAE** | | | | | |
| Silvery mole-rat *Heliophobius argenteocinereus* | YES | YES | YES | YES | LC |
| African mole-rat *Fukomys whytei* | YES | NO | NO | NO | LC |
| **Family HYSTRICIDAE** | | | | | |
| Cape porcupine *Hystrix africaeaustralis* | YES | YES | YES (NWS) | ?? | LC |
| **Family THRYONOMYIDAE** | | | | | |
| Greater canerat *Thryonomys swinderianus* | YES | YES | YES | YES | LC |
| Lesser canerat *Thryonomys gregorianus* | YES | ?? | NO | ?? | LC |

| Mammal species | Historically occurred in Malawi | Historically occurred in the EM | This study: found at the EM | Today expected in the EM | IUCN Redlist and CITES status# |
|---|---|---|---|---|---|
| **Family SCIURIDAE** | | | | | |
| Mutable sun squirrel *Heliosciurus mutabilis* | YES | YES | NO | YES | LC |
| Red bush squirrel *Paraxerus palliatus* | YES | YES | NO | ?? | LC |
| Smith's bush (Tree) squirrel *Paraxerus cepapi* | YES | YES | YES | YES | LC |
| Striped bush squirrel *Paraxerus flavovittis* | YES | ?? | NO | ?? | LC |
| Black and red bush squirrel *Paraxerus lucifer* | YES | NO | NO | NO | DD |
| Svynnerton's bush squirrel *Paraxerus vexillarius* | YES | NO | NO | NO | NT |
| **Family ANOMALURIDAE** | | | | | |
| Lord Derby's scaly-tailed "flying" squirrel *Anomalurus derbianus* | YES | NO | NO | NO | LC |
| **Family GLIRIDAE** | | | | | |
| Woodland dormouse *Graphiurus murinus* | YES | NO | NO | NO | LC |
| Kellen's dormouse *Graphiurus kelleni* | YES | NO | NO | NO | LC |
| Johnston's African dormouse *Graphiurus johnstoni* | YES | NO | NO | NO | DD |
| Small-eared dormouse *Graphiurus microtis* | YES | YES | NO | YES | LC |
| **Family NESOMYIDAE** | | | | | |
| Long-tailed pouched rat *Beamys major* | YES | YES | NO | YES | LC |
| Northern giant pouched rat *Cricetomys ansorgei* | YES | YES | YES | YES | LC |
| Southern African pouched mouse *Saccostomus campestris* | YES | YES | NO | YES | LC |
| Gray African climbing mouse *Dendromus melanotis* | YES | YES | NO | YES | LC |
| Nyika climbing mouse *Dendromus nyikae* | YES | YES | NO | YES | LC |
| Brant's Climbing Mouse *Dendromus nyasae* | YES | NO | NO | NO | LC |
| Chestnut climbing mouse Dendromus mystacalis | YES | YES | NO | YES | LC |
| Montane African Climbing Mouse *Dendromus insignis* | YES | NO | NO | NO | LC |
| Fat mouse *Steatomys pratensis* | YES | YES | YES | YES | LC |
| Tiny fat mouse Steatomys parvus | YES | YES | NO | YES | LC |
| **Family MURIDAE** | | | | | |
| Spiny mouse *Acomys spinosissimus* | YES | YES | NO | YES | LC |
| Brush-furred *Lophuromys machangui* | YES | YES | NO | YES | LC |
| Rudd's bristle-furred rat *Uranomys ruddi* | YES | YES | NO | YES | LC |
| Boehm's Gerbil *Gerbilliscus boehmi* | YES | ?? | NO | NO | LC |
| Bushveld gerbil *Gerbilliscus leucogaster* | YES | YES | YES | YES | LC |
| Red veld rat *Aethomys chrysophilus* | YES | YES | NO | YES | LC |
| Kaiser's Rock Rat *Aethomys kaiseri* | YES | NO | NO | NO | LC |
| Nyika Rock Rat *Aethomys nyikae* | YES | YES | NO | YES | LC |

| Mammal species | Historically occurred in Malawi | Historically occurred in the EM | This study: found at the EM | Today expected in the EM | IUCN Redlist and CITES status# |
|---|---|---|---|---|---|
| African marsh rat *Dasymys* cf *incomtus* | YES | YES | YES | YES | LC |
| Woodland thicket rat *Grammomys dolichurus* | YES | YES | NO | YES | LC |
| Ruwenzori thicket rat *Grammomys ibeanus* | YES | YES | NO | YES | LC |
| *Hylomyscus kaimosae* | ?? | NO | NO | NO | DD |
| Single-striped grass mouse *Lemniscomys rosalia* | YES | YES | YES | YES | LC |
| Heuglin's striped grass mouse *Lemniscomys zebra* | YES | NO | NO | NO | LC |
| Natal multimammate mouse *Mastomys natalensis* | YES | YES | YES | YES | LC |
| Namaqua rock rat *Micaelamys namaquensis* | YES | NO | NO | NO | LC |
| Grey-bellied pygmy mouse *Mus triton* | YES | ?? | NO | ?? | LC |
| Neave’s pygmy mouse *Mus neavei* | YES | ?? | NO | ?? | DD |
| Pygmy mouse *Mus minutoides* | YES | YES | YES | YES | LC |
| House mouse *Mus musculus* | NO | NO | NO | YES | LC |
| African Groove-toothed Rat *Mylomys dybowskii* | YES | NO | NO | NO | LC |
| Angoni vlei rat *Otomys angoniensis* | YES | YES | NO | YES | LC |
| Tanzanian vlei rat *Otomys lacustris* | YES | NO | NO | NO | VU |
| Creek grooved-toothed swamp rat *Pelomys fallax* | YES | YES | YES | YES | LC |
| East African Praomys *Praomys delectorum* | YES | YES | NO | YES | LC |
| House rat *Rattus rattus* | NO | NO | NO | YES | LC |
| Four-striped Grass Mouse *Rhabdomys dilectus* | YES | ?? | NO | ?? | LC |
| Acacia rat *Thallomys paedulcus* | YES | YES | NO | YES | LC |
| Hildegarde's broad-headed mouse *Zelotomys hildegardeae* | YES | NO | NO | NO | LC |
| **Order PRIMATES** | | | | | |
| **Family GALAGIDAE** | | | | | |
| Greater (or Thick-tailed) galago *Otolemur crassicaudatus* | YES | YES | YES | YES | LC; CITES 2 |
| Southern lesser galago (Bushbaby) *Galago moholi* | YES | YES | ?? | ?? | LC; CITES 2 |
| Grant's lesser galago *Galagoides granti* | YES | NO | NO | NO | LC; CITES 2 |
| **Family CERCOPITHECIDAE** | | | | | |
| Yellow baboon *Papio cynocephalus* | YES | YES | YES (migrate between conservation areas) | NO | LC; CITES 2 |
| Vervet monkey *Chlorocebus pygerythrus* | YES | YES | YES | YES | LC; CITES 2 |
| Sykes’ monkey *Cercopithecus mitis* | YES | YES | YES | YES | LC; CITES 2 |
| **Order PHOLIDOTA** | | | | | |
| **Family MANIDAE** | | | | | |

| Mammal species | Historically occurred in Malawi | Historically occurred in the EM | This study: found at the EM | Today expected in the EM | IUCN Redlist and CITES status# |
|---|---|---|---|---|---|
| Temminck's ground pangolin *Smutsia temminckii* | YES | YES | YES (NP) | ?? | VU; CITES 2 |
| **Order EULIPOTYPHLA** | | | | | |
| **Family SORICIDAE** | | | | | |
| Greater dwarf shrew *Suncus lixus* | YES | YES | NO | NO | LC |
| Lesser dwarf shrew *Suncus varilla* | YES | YES | NO | NO | LC |
| Climbing dwarf shrew *Suncus megalura* | YES | YES | NO | YES | LC |
| Olivier's musk shrew *Crocidura olivieri* | YES | YES | NO | YES | LC |
| Bicolored musk shrew *Crocidura fuscomurina* | YES | YES | YES | YES | LC |
| Reddish-grey musk shrew *Crocidura cyanea* | YES | YES | NO | YES | LC |
| Greater grey-brown musk shrew *Crocidura luna* | YES | YES | NO | YES | LC |
| Lesser red musk shrew *Crocidura hirta* | YES | YES | NO | YES | LC |
| **Family ERINACEIDAE** | | | | | |
| White-bellied hedgehog *Atelerix albiventris* | YES | YES | YES | YES | LC |
| **Order CHIROPTERA** | | | | | |
| **Suborder PTEROPODIFORMES** | | | | | |
| **Family PTEROPODIDAE** | | | | | |
| Ansell's epauletted fruit bat *Epomophorus anselli* | YES | NO | NO | NO | DD |
| Peters's epauletted fruit bat *Epomophorus crypturus* | YES | YES | NO | YES | LC |
| Little epauletted fruit bat *Epomophorus labiatus* | YES | YES | NO | YES | LC |
| Wahlberg's epauletted fruit bat *Epomophorus wahlbergi* | YES | YES | YES | YES | LC |
| Dobson's fruit bat *Epomops dobsonii* | YES | NO | NO | NO | LC |
| Straw-coloured fruit bat *Eidolon helvum* | YES | YES | NO | YES | NT |
| Egyptian rousette *Rousettus aegyptiacus* | YES | YES | NO | YES | LC |
| Long-haired rousette *Rousettus lanosus* | YES | NO | NO | NO | LC |
| Angolan soft-furred fruit bat *Lissonycteris angolensis* | YES | NO | NO | NO | LC |
| Peters's lesser epauletted fruit bat *Micropteropus pusillus* | YES | NO | NO | NO | LC |
| Anchieta's broad-faced fruit bat *Plerotes anchietae* | YES | NO | NO | NO | DD |
| **Family HIPPOSIDERIDAE** | | | | | |
| Giant leaf-nosed bat *Hipposideros gigas* | YES | YES | NO | YES | LC |
| Striped leaf-nosed bat *Hipposideros vittatus* | YES | YES | NO | YES | NT |
| Sundevall's leaf-nosed bat *Hipposideros caffer* | YES | YES | NO | YES | LC |
| Noack's leaf-nosed bat *Hipposideros ruber* | YES | YES | NO | YES | LC |
| Percival's short-eared trident bat *Cloeotis percivali* | YES | ?? | NO | ?? | LC |
| Persian trident bat *Triaenops persicus* | YES | YES | NO | YES | LC |

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|---|---|---|---|---|---|
| **Family RHINOLOPHIDAE** | | | | | |
| Hildebrandt's horseshoe bat *Rhinolophus hildebrandtii* | YES | YES | NO | YES | LC |
| Rüppell's horseshoe bat *Rhinolophus fumigatus* | YES | YES | NO | YES | LC |
| Geoffroy's horseshoe bat *Rhinolophus clivosus* | YES | YES | NO | YES | LC |
| Darling's horseshoe bat *Rhinolophus darlingi* | YES | ?? | NO | ?? | LC |
| Lander's horseshoe bat *Rhinolophus landeri* | YES | YES | NO | YES | LC |
| Blasius's horseshoe bat *Rhinolophus blasii* | YES | YES | NO | YES | LC |
| Bushveld horseshoe bat *Rhinolophus simulator* | YES | ?? | NO | ?? | LC |
| Swinny's horseshoe bat *Rhinolophus swinnyi* | YES | ?? | NO | ?? | LC |
| **Family MEGADERMATIDAE** | | | | | |
| Yellow-winged bat *Lavia frons* | YES | YES | YES | YES | LC |
| **Suborder VESPERTILIONIFORMES** | | | | | |
| **Family EMBALLONURIDAE** | | | | | |
| Mauritian tomb bat *Taphozous mauritianus* | YES | YES | YES | YES | LC |
| **Family NYCTERIDAE** | | | | | |
| Hairy slit-faced bat *Nycteris hispida* | YES | YES | NO | YES | LC |
| Large slit-faced bat *Nycteris grandis* | YES | YES | NO | YES | LC |
| Wood's slit-faced bat *Nycteris woodi* | YES | YES | NO | YES | LC |
| Large-eared slit-faced bat *Nycteris macrotis* | YES | YES | NO | YES | LC |
| Egyptian slit-faced bat *Nycteris thebaica* | YES | YES | NO | YES | LC |
| **Family MOLOSSIDAE** | | | | | |
| Large-eared giant mastiff bat *Otomops martiensseni* | YES | NO | NO | NO | NT |
| Midas free-tailed bat *Mops midas* | YES | NO | NO | NO | LC |
| Angola free-tailed bat *Mops condylurus* | YES | YES | YES | YES | LC |
| White-bellied free-tailed bat *Mops niveiventer* | YES | NO | NO | NO | LC |
| Nigerian free-tailed bat *Chaerephon nigeriae* | YES | NO | NO | NO | LC |
| Spotted free-tailed bat *Chaerephon bivittatus* | YES | ?? | NO | ?? | LC |
| Little free-tailed bat *Chaerephon pumilus* | YES | YES | YES | YES | LC |
| Ansorge's free-tailed bat *Chaerephon ansorgei* | YES | ?? | NO | ?? | LC |
| African giant free-tailed bat *Tadarida ventralis* | YES | YES | NO | YES | DD |
| Malagasy Free-tailed Bat *Tadarida fulminans* | YES | NO | NO | NO | LC |
| Egyptian free-tailed bat *Tadarida aegyptiaca* | ?? | NO | NO | NO | LC |
| **Family MINIOPTERIDAE** | | | | | |
| Greater long-fingered bat *Miniopterus inflatus* | YES | ?? | NO | ?? | LC |
| Lesser long-fingered bat *Miniopterus fraterculus* | YES | NO | NO | NO | LC |
| Natal long-fingered bat *Miniopterus natalensis* | YES | YES | YES | YES | LC |

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|---|---|---|---|---|---|
| **Family VESPERTILIONIDAE** | | | | | |
| Anchieta's pipistrelle *Hypsugo anchietae* | ?? | NO | NO | NO | LC |
| Rusty pipistrelle *Pipistrellus rusticus* | YES | ?? | NO | ?? | LC |
| African pipistrelle *Pipistrellus hesperidus* | YES | NO | NO | NO | LC |
| Rüppell's pipistrelle *Pipistrellus rueppelli* | YES | ?? | NO | ?? | LC |
| Dobson's pipistrelle *Pipistrellus grandidieri* | YES | NO | NO | NO | NE |
| Cape serotine *Neoromicia capensis* | YES | ?? | NO | ?? | LC |
| Kruger serotine *Neoromicia cf. melckorum* | YES | NO | NO | NO | DD |
| Banana bat *Neoromicia nana* | YES | YES | NO | YES | LC |
| Rendall's serotine *Neoromicia rendalli* | YES | YES | NO | YES | LC |
| Zulu serotine *Neoromicia zuluensis* | YES | YES | NO | YES | LC |
| Welwitsch's myotis *Myotis welwitschii* | YES | YES | NO | YES | LC |
| Temminck's myotis *Myotis tricolor* | YES | NO | NO | NO | LC |
| Rufous myotis *Myotis bocagii* | YES | YES | NO | YES | LC |
| Botswana long-eared bat *Laephotis botswanae* | YES | NO | NO | NO | LC |
| Long-tailed serotine *Eptesicus hottentotus* | YES | YES | NO | YES | LC |
| Common butterfly bat *Glauconycteris argentata* | YES | NO | NO | NO | LC |
| Variegated butterfly bat *Glauconycteris variegata* | YES | YES | NO | YES | LC |
| Giant yellow house bat *Scotophilus nigrita* | YES | YES | NO | YES | LC |
| Yellow-bellied house bat *Scotophilus dinganii* | YES | YES | YES | YES | LC |
| Green house bat *Scotophilus viridis* | YES | NO | NO | NO | LC |
| White-bellied yellow bat *Scotophilus leucogaster* | YES | ?? | NO | ?? | LC |
| Schlieffen's twilight bat *Nycticeinops schlieffeni* | YES | YES | YES | YES | LC |
| Thomas's house bat *Scotoecus albofuscus* | YES | YES | NO | YES | DD |
| Dark-winged lesser house bat *Scotoecus hindei/albigula* | YES | YES | NO | YES | DD |
| Damara woolly bat *Kerivoula argentata* | YES | ?? | NO | ?? | LC |
| Lesser woolly bat *Kerivoula lanosa* | YES | YES | NO | YES | LC |
| Thomas's flat-headed bat *Mimetillus thomasi* | YES | YES | NO | YES | LC |
| **Order CARNIVORA** | | | | | |
| **Family HYAENIDAE** | | | | | |
| Spotted hyaena *Crocuta crocuta* | YES | YES | NO | NO | LC |
| **Family FELIDAE** | | | | | |
| Cheetah *Acinonyx jubatus* | YES | YES | NO | NO | VU; CITES 1 |
| Leopard *Panthera pardus* | YES | YES | NO | ?? | NT; CITES 1 |
| Lion *Panthera leo* | YES | YES | NO | NO | VU CITES 2 |

| Mammal species | Historically occurred in Malawi | Historically occurred in the EM | This study: found at the EM | Today expected in the EM | IUCN Redlist and CITES status# |
|---|---|---|---|---|---|
| Caracal *Caracal caracal* | YES | YES | NO | YES | LC; CITES 2 |
| African wild cat *Felis silvestris* | YES | YES | YES | YES | LC; CITES 2 |
| Serval *Leptailurus serval* | YES | YES | YES | YES | LC; CITES 2 |
| **Family VIVERRIDAE** | | | | | |
| African civet *Civettictis civetta* | YES | YES | YES | YES | LC |
| Common large-spotted genet *Genetta maculata* | YES | YES | NO | YES | LC |
| Angolan genet *Genetta angolensis* | YES | YES | YES | YES | LC |
| African palm civet *Nandinia binotata* | YES | YES | NO | YES | LC |
| **Family HERPESTIDAE** | | | | | |
| Selous' mongoose *Paracynictis selousi* | YES | NO | NO | NO | LC |
| Large grey mongoose *Herpestes ichneumon* | YES | YES | NO | YES | LC |
| Slender mongoose *Galerella sanguinea* | YES | YES | NO | YES | LC |
| Meller's mongoose *Rhynchogale melleri* | YES | YES | NO | YES | LC |
| Bushy-tailed mongoose *Bdeogale crassicauda* | YES | YES | NO | YES | LC |
| White-tailed mongoose *Ichneumia albicauda* | YES | YES | NO | YES | LC |
| Water (Marsh) mongoose *Atilax paludinosus* | YES | YES | YES | YES | LC |
| Banded mongoose *Mungos mungo* | YES | YES | NO | YES | LC |
| Dwarf mongoose *Helogale parvula* | YES | YES | NO | YES | LC |
| **Family CANIDAE** | | | | | |
| Bat-eared fox *Otocyon megalotis* | ?? | ?? | NO | NO | LC |
| African wild dog *Lycaon pictus* | YES | YES | NO | NO | EN |
| Side-striped jackal *Canis adustus* | YES | YES | YES | YES | LC |
| **Family MUSTELIDAE** | | | | | |
| Cape clawless otter *Aonyx capensis* | YES | YES | YES | YES | NT; CITES 2 |
| Spotted-necked otter *Hydrictis maculicollis* | YES | YES | YES | YES | NT; CITES 2 |
| Honey badger (Ratel) *Mellivora capensis* | YES | YES | NO | ?? | LC |
| African striped weasel *Poecilogale albinucha* | YES | YES | YES | YES | LC |
| Striped polecat *Ictonyx striatus* | YES | YES | NO | YES | LC |
| **Order PERISSODACTYLA** | | | | | |
| **Family RHINOCEROTIDAE** | | | | | |
| Square-lipped (White) rhinoceros *Ceratotherium simum* | YES | YES | NO | NO | NT; CITES 1 |
| Hook-lipped (Black) rhinoceros *Diceros bicornis* | YES | YES | NO | NO | CR; CITES 1 |
| **Family EQUIDAE** | | | | | |
| Plains zebra *Equus quagga* | YES | ?? | YES (NP) | NO | LC |
| **Order SUIFORMES** | | | | | |
| **Family SUIDAE** | | | | | |

| Mammal species | Historically occurred in Malawi | Historically occurred in the EM | This study: found at the EM | Today expected in the EM | IUCN Redlist and CITES status# |
|---|---|---|---|---|---|
| Bushpig *Potamochoerus larvatus* | YES | YES | NO | YES | LC |
| Common warthog *Phacochoerus africanus* | YES | YES | YES | YES | LC |
| **Order WHIPPOMORPHA** | | | | | |
| **Family HIPPOPOTAMIDAE** | | | | | |
| Hippopotamus *Hippopotamus amphibius* | YES | YES | YES | YES | VU |
| **Order CETARTIODACTYLA** | | | | | |
| **Family GIRAFFIDAE** | | | | | |
| Giraffe *Giraffa camelopardalis* | YES | NO | YES (NP & NWS) | NO | LC |
| **Family BOVIDAE** | | | | | |
| African buffalo *Syncerus caffer* | YES | YES | YES (NP, NWS) | ?? | LC |
| Greater kudu *Tragelaphus strepsiceros* | YES | YES | YES (NWS) | ?? | LC |
| Nyala *Tragelaphus angasii* | YES | YES | YES (NP & NWS) | ?? | LC |
| Bushbuck *Tragelaphus scriptus* | YES | YES | YES (NP & NWS) | ?? | LC |
| Common eland *Tragelaphus oryx* | YES | YES | NO | NO | LC |
| Blue wildebeest *Connochaetes taurinus* | YES | YES | YES (NP & NWS) | NO | LC |
| Lichtenstein's hartebeest *Alcelaphus lichtensteinii* | YES | YES | NO | NO | LC |
| Tsessebe *Damaliscus lunatus* | ?? | ?? | NO | NO | LC |
| Sable *Hippotragus niger* | YES | YES | NO | NO | LC |
| Roan *Hippotragus equinus* | YES | ?? | NO | NO | LC |
| Natal red duiker *Cephalophus natalensis* | YES | YES | NO | ?? | LC |
| Harvey's red duiker *Cephalophus harveyi* | YES | ?? | NO | NO | LC |
| Common duiker *Sylvicapra grimmia* | YES | YES | YES (NP & NWS) | ?? | LC |
| Blue duiker *Philantomba monticola* | YES | YES | NO | ?? | LC |
| Common (Southern) reedbuck *Redunca arundinum* | YES | YES | YES (NWS) | ?? | LC |
| Waterbuck *Kobus ellipsiprymnus* | YES | YES | YES (NP & NWS) | ?? | LC |
| Puku *Kobus vardonii* | YES | ?? | NO | NO | NT |
| Sharpe's grysbok *Raphicerus sharpei* | YES | YES | NO | ?? | LC |
| Impala *Aepyceros melampus* | YES | YES | YES (NWS) | NO | LC |
| Klipspringer *Oreotragus oreotragus* | YES | YES | NO | NO | LC |
| Suni *Neotragus moschatus* | YES | YES | YES (NWS) | ?? | LC |
| Oribi *Ourebia ourebi* | YES | ?? | NO | NO | LC |

## B: Locations of mammal sightings and signs

Yellow-winged bat *Lavia frons* (not previously found to be present in the study area)

- S16° 16.512' E34° 55.142'

Mauritian tomb bat *Taphozous mauritianus*

- *S16° 10.905' E34° 51.433'*

Vervet monkey *Chlorocebus pygerythrus*

- *S16° 10.738' E34° 51.537'*
- *S16° 10.437' E34° 51.640'*
- *S16° 10.245' E34° 51.732'*
- *S16° 10.504' E34° 51.512'*
- *S16° 10.755' E34° 51.529'*
- *S16° 10.838' E34° 51.553'*
- *S16° 10.785' E34° 51.641'*
- *S16° 10.695' E34° 51.790'*
- *S16° 10.617' E34° 51.915'*

Cape clawless otter *Aonyx capensis* (spoor)

- S16° 20.728' E35° 00.765'

Water (Marsh) mongoose *Atilax paludinosus* (spoor)

- *S16° 20.748' E35° 00.755'*
- *S16° 24.185' E35° 03.127'*
- *S16° 10.227' E34° 51.705'*

African wild cat *Felis silvestris* (spoor)

- *S16° 10.819' E34° 51.431'*
- *S16° 10.488' E34° 51.601'*

Angolan genet *Genetta angolensis* (dead on road)

- *S16° 16.552' E34° 55.080'*

Side-striped jackal *Canis adustus*

- *S16° 10.458' E34° 52.000'*

Giraffe *Giraffa camelopardalis*

- *S16° 10.499' E34° 51.547'*
- *S16° 10.497' E34° 51.631'*

Common duiker *Sylvicapra grimmia*

- *S16° 10.847' E34° 51.427'*

Nyala *Tragelaphus angasii*

- *S16° 10.779' E34° 51.466'*
- *S16° 10.377' E34° 51.619'*
- *S16° 10.504' E34° 51.512'*
- *S16° 10.749' E34° 51.700'*
- *S16° 10.695' E34° 51.790'*

Impala *Aepyceros melampus*

- *S16° 10.637' E34° 51.531'*
- *S16° 10.437' E34° 51.640'*
- *S16° 10.377' E34° 51.619'*
- *S16° 10.170' E34° 51.971'*
- *S16° 10.838' E34° 51.553'*
- *S16° 10.617' E34° 51.915'*

Plains zebra *Equus quagga*

- *S16° 10.503' E34° 51.599'*
- *S16° 10.576' E34° 52.002'*

Hippopotamus *Hippopotamus amphibious*

- *S16° 22.706' E35° 3.029' (10 March 2016 - 4 individuals, seen from microlight)*
- *S16° 23.749' E35° 2.549' (10 March 2016 - 2 individuals, seen from microlight)*
- *S16° 16.885' E34° 55.209' (20 January 2016 - 3 individuals, seen from boat)*
- *S16° 16.524' E34° 55.218' (7 March 2016 - 1 individual, seen from the Illovo Sports Club)*
- *S16° 30.907' E35° 6.906' (19 January 2016 - 1 individual heard, but not seen)*
- *S16° 32.103' E35° 4.310' (April & May 2016 - female & calf regular visitors to*