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VEGETATION STUDIES OF SELECTED ISLANDS AND ADJACENT MAINLAND ON LAKE KARIBA, ZIMBABWE

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Abstract

The objective of this study was to classify and describe the vegetation of selected islands on Lake Kariba. A total of forty-six islands were surveyed. Two hundred and eleven samples were classified into twenty-six vegetation types. The types were described in terms of their location, floristic composition and factors that determine or influence them. Woodlands consisted of ten types: Colophospermum mopane woodland, Colophospermum mopane-Combretum apiculatum woodland, Colophospermum mopane mixed woodland, Combretum apiculatum mixed woodland, Mixed Combretum woodland, Combretum elaeagnoides mixed woodland, Julbernardia globiflora woodland, Ficus sycomorus woodland, Acacia nilotica woodland and Acacia nigrescens-Afzelia quanzensis mixed woodland. Thickets and woodland thickets consisted of four types: Karomia tettensis thicket, Diospyros quiloensis thicket, Combretum celastroides woodland thicket and Guibourtia conjugata woodland thicket. Shrublands consisted of five types: Colophospermum mopane shrubland, Mundulea sericea shrubland, Croton menyhartii shrubland, Pteliopsis myrtifolia shrubland and Indigofera tinctoria shrubland. Grasslands consisted of seven types: Melinis repens wooded grassland, Panicum repens grassland, Aristida rhiniochloa grassland, Aristida adscensionis grassland, Heteropogon contortus grassland, Urochloa trichopus wooded grassland and Eragrostis viscosa wooded grassland. Populations of large herbivores, especially elephants are having a negative impact on vegetation structure and species composition on some of the islands. The influence of soil texture in determining species composition is also significant with most thickets and woodlands occurring on sands. Twenty-nine years of isolation from the mainland has not had a significant influence on species richness and composition of the vegetation of the islands.

Introduction

Background

The construction of Kariba dam in 1958 and the consequent flooding of the valley floor created 293 islands in Lake Kariba. Most of the islands originated from geological faulting and uplifting. This created groups of islands lying in roughly parallel chains, the main axis being in a north-east/south-west direction (Lake Kariba Coordinating Committee 1960). This is clearly illustrated by the Sibilobilo Group where islands occur in a series of parallel lines. The smaller islands are former ridges and hilltops within the valley. There are 190 islands on the Zimbabwean side and 103 on the Zambian side (Balon and Coche 1974).

Island ecosystems possess several desirable features with respect to their potential for ecological research (Choate 1975). They are less complex, can be used to test hypotheses in the absence of specific uncontrolled variables present under mainland conditions and can be compared with mainland situations to elucidate ecological processes (Attwell and Bhika 1985). Lake Kariba islands can therefore be used to test botanical and ecological hypotheses, such as determining the effect of isolation on species richness, composition and vegetation structure. The islands are unique in Zimbabwe and some are relatively undisturbed owing to their limited accessibility to humans. The fact that the islands were previously attached to the neighbouring mainland until approximately 1968, and thus are of known age, gives them potential value to test some aspects of island biogeographical theory in the short term.

Potential threats

The islands on Lake Kariba are faced with two main threats, increasing land pressure and confusion over the jurisdiction of the islands in Lake Kariba (Lake Kariba Fisheries Research Institute 1996). Some of the islands in Lake Kariba are within the Recreation Park managed by the Department of National Parks and Wildlife Management, some are part of the Sibilobilo Safari Area, and some are under the jurisdiction of Kariba Town Council. This confusion is compounded by the fact that due to the fall in the lake level, many of these islands, particularly large ones such as Zebra, Tsetse, Fothergill and Spurwing, have for many years been part of the mainland. This has resulted in some islands being used for settlement, or, in one case in Binga, being leased to a private developer by the Rural District Council (Lake Kariba Fisheries Research Institute 1996).

Kariba is a flourishing tourist centre and demand for land for development is high. Due to rapid development for tourism and increasing land pressure, it is possible that in the foreseeable future some of the largest islands will be targeted for development since most are not yet inhabited and there are no permanent structures. Islands or areas of particular botanical interest within the lake should be identified and conservation issues considered during the planning process, if any developments are to take place on some of the islands. This study aims to provide baseline data required for the monitoring of the effects of future developments on the vegetation.

Previous vegetation studies

Few floristic studies have been done on the islands in Lake Kariba. Research has been carried out mainly on fisheries and the aquatic environment. However, studies have been done on shoreline vegetation (Magadza 1970; Skarpe 1997) and on aquatic macrophytes (Machena 1989; Mitchell 1970).

White (1965;1976) described Lake Kariba as being situated in the 'Karibian Subcentre of the Zambezian Regional Centre of Endemism'. The vegetation type of the Zambezi Valley, in which the islands fall is predominantly savanna woodland dominated by *Colophospermum mopane* interspersed with thicket vegetation (Wild and Barbosa 1967; Child 1968; Balón and Coche 1974). The terrestrial vegetation of the flooded valley was principally deciduous except for a narrow fringe of evergreen trees on fertile alluvium along rivers (Balon and Coche 1974). A close relationship was noted to exist between vegetation and soil (Scudder 1962). Most of the riverine vegetation and much of the mopane woodland are now under water. In general, the predominant vegetation cover on the islands consists of *Colophospermum mopane* woodland similar to that previously described for the valley. This can vary from scrub mopane in rugged higher areas to open mopane woodland on the mid-slope of the islands. Most of the islands are now inhabited by populations of large herbivores, especially elephants, that are having a negative impact on vegetation structure and species composition (Mapaure and Mhlanga, in prep.).

Most studies on the islands have been conducted on one or a few islands. Schramm (1978) found that the predominant vegetation type on Dinosaur island (125/126) was *Colophospermum mopane* woodland but he distinguished ten micro-community types according to species dominance. Soil was the major determinant of plant communities. Dyer (1985), in his study of Dinosaur Island, in Sibilobilo area, also found out that *Colophospermum mopane* was not the dominant species in the ecological units that he defined. Instead, the vegetation is described as savanna woodland with several communities determined by underlying geology. Attwell and Bhika (1985) classified the vegetation on Starvation island into two major vegetation types. The main vegetation type was dominated by *Karomia tettensis*, *Combretum elaeagnoides*, *Combretum apiculatum* and *Diospyros quiloensis* and was heavily damaged by elephants. The second vegetation type was *Panicum repens* grassland which occurred on the bottom slope surrounding the island. Frost (1987) described the vegetation on Zebra and Antelope islands as being dominated by *Colophospermum mopane* with smaller numbers of *Kirkia acuminata*, *Adansonia digitata*, *Diospyros quiloensis* and *Combretum* species.

The recent communal land vegetation survey by Timberlake *et al.*, (1993) which emphasized a vegetation type/habitat basis to determine soil-plant relations found out that *Colophospermum mopane* woodland in Kariba District is mostly confined to the heavier soils. *Combretum* shrubland was found to be common on the basaltic soils in Omay. We therefore hypothesized that the vegetation types on these islands are complex, their structure and composition being determined by a wide range of factors, including underlying geology, type and depth of soil, distance from the nearest land mass, size of the island and the impact of large herbivores.

Objectives

The aim of the project was to study selected islands on the Zimbabwean side of Lake Kariba, with a view to provide detailed vegetation classification, ordination and descriptions of representative areas. Specific objectives were:

1. To survey the vegetation of selected islands in Lake Kariba,
2. To determine factors that influence species composition and richness,
3. Identify islands of vegetation conservation interest.

Study area

A total of 46 islands (Table 1) were studied in Basins 2 to 5 in Lake Kariba. Lake Kariba (Figure 1) stretches for 276 km in an east-west direction bordering Zambia and Zimbabwe.

Most of the islands in Lake Kariba are found in chains especially in the Sibilobilo area. They vary considerably in size, the smallest on the Zimbabwean side being 0.5 ha and the largest 804.3 ha in extent.

Table 1. Sizes, distances from the mainland and number of species on the surveyed islands

Island	Distance from nearest mainland (km)	Approximate Area (ha)	Number of Species
Sampakaruma-161	5.9	4.0	21
Sampakaruma-162	2.7	69.5	79
Sampakaruma-163	2.8	5.3	31
Sampakaruma-164	2.2	18.5	47
Sampakaruma-165	2.4	2.3	36
Rhino	5.0	4.0	14
Redcliff	5.3	31.0	48
Antelope	2.1	379.0	74
Zebra	1.0	154.5	47
Tsetse	2.6	28.0	53
Long	9.9	60.0	56
Starvation	2.1	114.3	9
Lubangwa	2.6	41.5	27
Island 126/127	2.5	25.8	33
Snake	1.0	1.3	33
Namambere	1.4	804.3	77
Island 123	5.2	2.5	29
Island 124	5.0	14.3	16
Patridge	4.4	84.5	32
Balabi	4.8	10.8	35
Weather	2.9	120.0	48
Island 40 mile	2.1	7.8	34
Marker	1.1	5.8	102
Elephant	0.3	59.8	69
Christmas	0.5	95.8	76
Island 49	1.6	2.3	62
Masuko	1.3	82.0	60
Mbeta	1.0	93.3	101
Masuntu	2.5	32.0	52
Kangamani	1.4	91.3	39
Mubende	2.4	4.3	53
Kampaka	1.0	21.3	69
Nandavwi	1.6	245.8	72
Chasayi	0.2	303.8	88
Mambaleza	1.5	6.0	27
Seiche Tower	1.1	2.5	40
Pimple	5.6	2.5	26
Island 110	4.6	3.8	18
Island 129	3.0	2.3	7
Island Q	5.5	1.3	35
Island R	5.5	4.0	27
Namagwaba	0.4	422.3	40
Sampakaruma-160	5.6	3.5	37
Island P	6.0	0.5	22
Zinyama	0.5	24.0	17

Sizes of the islands vary annually and smaller ones appear and disappear with fluctuations in lake levels. When the lake level falls drastically, islands near the mainland are reconnected. Their shorelines are generally steep and the majority are covered with sandstone. Their total surface area is 147 km^2 and their shoreline totals 604 km (Balon and Coche 1974). There is a total of 293 islands in Lake Kariba 190 on the Zimbabwean side and 103 on the Zambian side (Table 2).

The geology of the Zambezi valley and the islands are described in detail by the Lake Kariba Coordinating Committee (1960). The lake lies mostly over sandstone and shales of the upper Karoo System. At the upstream end of the lake lies the apex of a large triangle of basaltic and rhyolitic lavas of the Karoo System, locally over 305 m thick. Conspicuous vertical joints occur in the rock representing old laval flows. This jointing enabled the Zambezi river and its tributaries to cut deeply in the lava to form a series of picturesque gorges and canyons including the Devil's gorge where the lake is confined for approximately 32 km of its length. Islands in this reach are restricted to five small rocky islets lying between the Deka and Gwaai rivers. At the other end of the lake the basement rocks have been exposed at Kariba Gorge. The major portion of the lake lies in the great trough of the Zambezi formed by the rifting movements and is composed almost entirely of sedimentary rocks of the Karoo System, although some volcanics are found in the Sibilobilo area. These sediments consist of alternating sandstones, shales and grits.

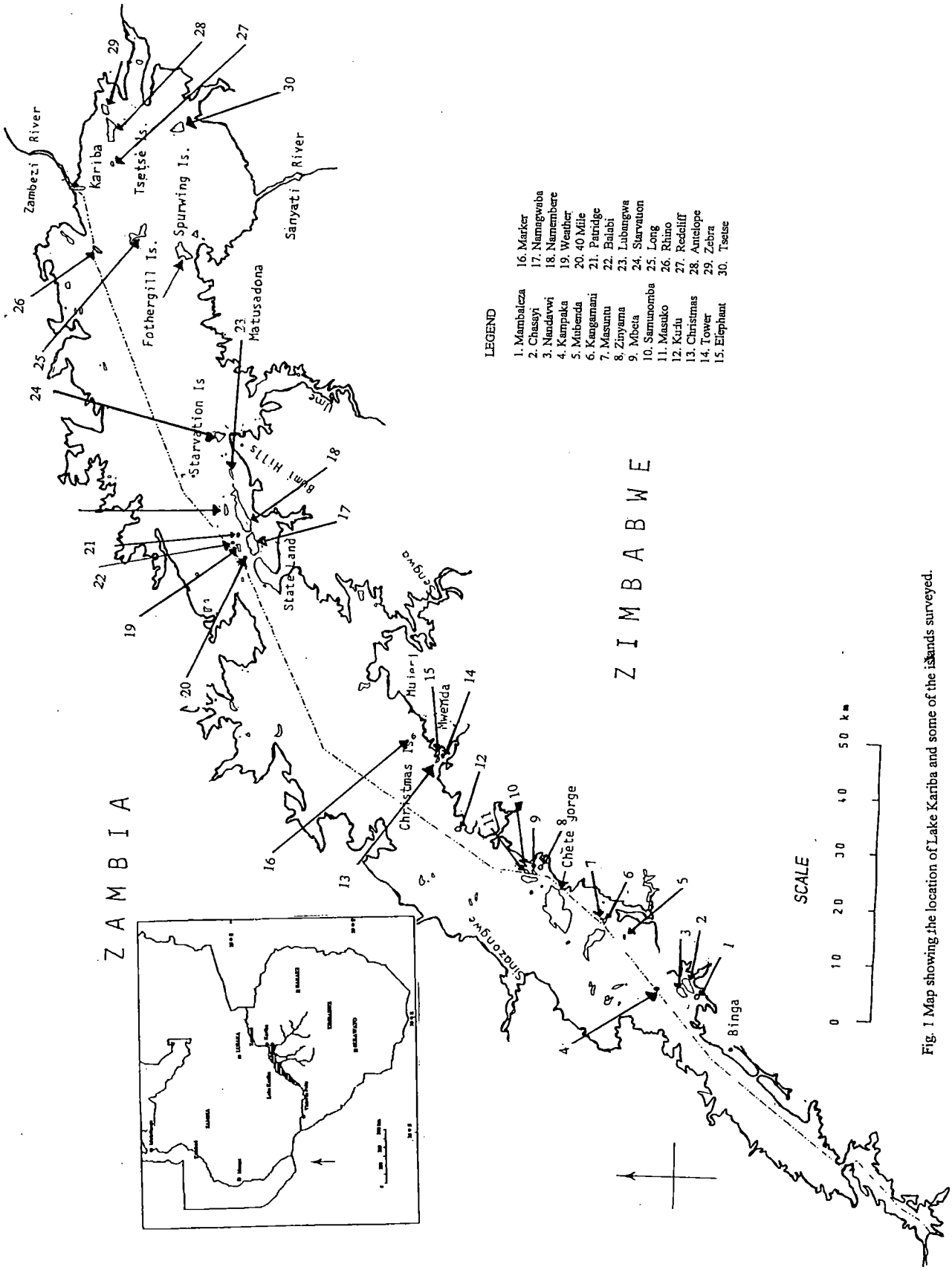


Fig. 1 Map showing the location of Lake Kariba and some of the islands surveyed.

Most of the islands consist of sandstone boulders and solid outcrops of sandstone. Sandy soils predominate

with some Kalahari sands in the upper reaches and clayey soils derived from shales on the southern side near Kariba (Lake Kariba Coordinating Committee 1960).

The climate of Kariba can be divided into four seasons based on temperature and rainfall; the cold-dry season (June to August), hot-dry season (September to November), hot-wet season (November to March), cool-dry season (March to May) (Bowmaker 1973). The warm season generally lasts from October to March during which period the mean monthly air temperature range is between 22°C-29°C. The cool period lasts from April to September and the lowest mean temperature (15°C) occur in June and July. The highest temperature during these two months is generally 25°C. Mean annual precipitation is 600 mm but this varies greatly from year to year. Rain starts sporadically in October, increasing slightly in November, and reaches its peak between December and February (Balon and Coche 1974).

Methods and materials

Data collection

The method used in this study followed that used during the vegetation survey of Communal lands of Zimbabwe (Timberlake *et al.* 1993). This method uses a phytosociological approach to vegetation classification and is based principally on floristic composition of the woody species rather than on vegetation structure. Preliminary stereo-photo interpretation of panchromatic aerial photographs (1:80 000; 1989 and 1990) for larger islands and adjacent mainland was done in order to stratify the vegetation into reasonably homogenous units, which were used as a framework for sampling. This was followed by field sampling which covered all the stratified types in areas of reasonably representative vegetation. Sampling was plotless. A random starting point was selected at each site and the investigators moved from that point covering an approximately circular area from the central point. In order to determine species composition, all woody and grass species occurring in the area were recorded and the area was expanded until no new species were encountered. Care was taken not to transgress any obvious environmental boundaries. All woody species were assessed for cover-abundance using a modified Braun-Blanquet Scale (Mueller-Dombois and Ellenberg 1974). Cover-abundance for grasses was determined using one 1 x 1 m quadrats randomly placed at each sampling site. Environmental data such as landscape type, soil type, grazing intensity and burning were also recorded. Soil samples were collected and analysed for exchangeable bases (K, Mg, and Ca), free Fe, cation exchange capacity, organic carbon and physical characteristics (% clay, % silt, % gravel, % coarse sand, % medium sand and % fine sand).

Data analysis

Species-cover data were analysed by Detrended Correspondence Analysis (DCA (Gauch 1982) a direct gradient analysis technique. DCA determines similarity relationships among vegetation samples and among species and calculates axes scores for each sample (or species). Vegetation types were derived from classification, ordination as well as field notes.

Results

Island characteristics

There is no human habitation on all the islands surveyed and none had permanent occupancy. A few had game viewing platforms, and telemetry and weather stations. Development plans, however, have been proposed for Sampakaruma group, Zebra, Antelope, Namembere, Masuku and Kangamani islands for tourist facilities: chalets, moaring facilities or lodges. The islands are of variable size and variable distance from the mainland (Table 1). For the islands surveyed the smallest island is 0.5 ha (Island P) and the largest is 804.25 ha (Namembere).

An attempt was made to compile whole island species lists, but they are not comprehensive (Table 1). A regression of sample species richness on island area and isolation (distance from the nearest mainland) was carried out to assess their relationship with species richness. There was generally a tendency for larger

Table 2: Distribution of islands in order of size

Area at full supply capacity of the Lake Ha	Number of Islands		
	Zambia	Zimbabwe	Total
2-4	17	59	76
5-10	34	60	94
11-20	20	29	49
21-40	11	15	26
41-200	13	18	31
201-405	5	5	10
0ver 405	3	4	7
Total no. of Islands	**103**	**190**	**293**

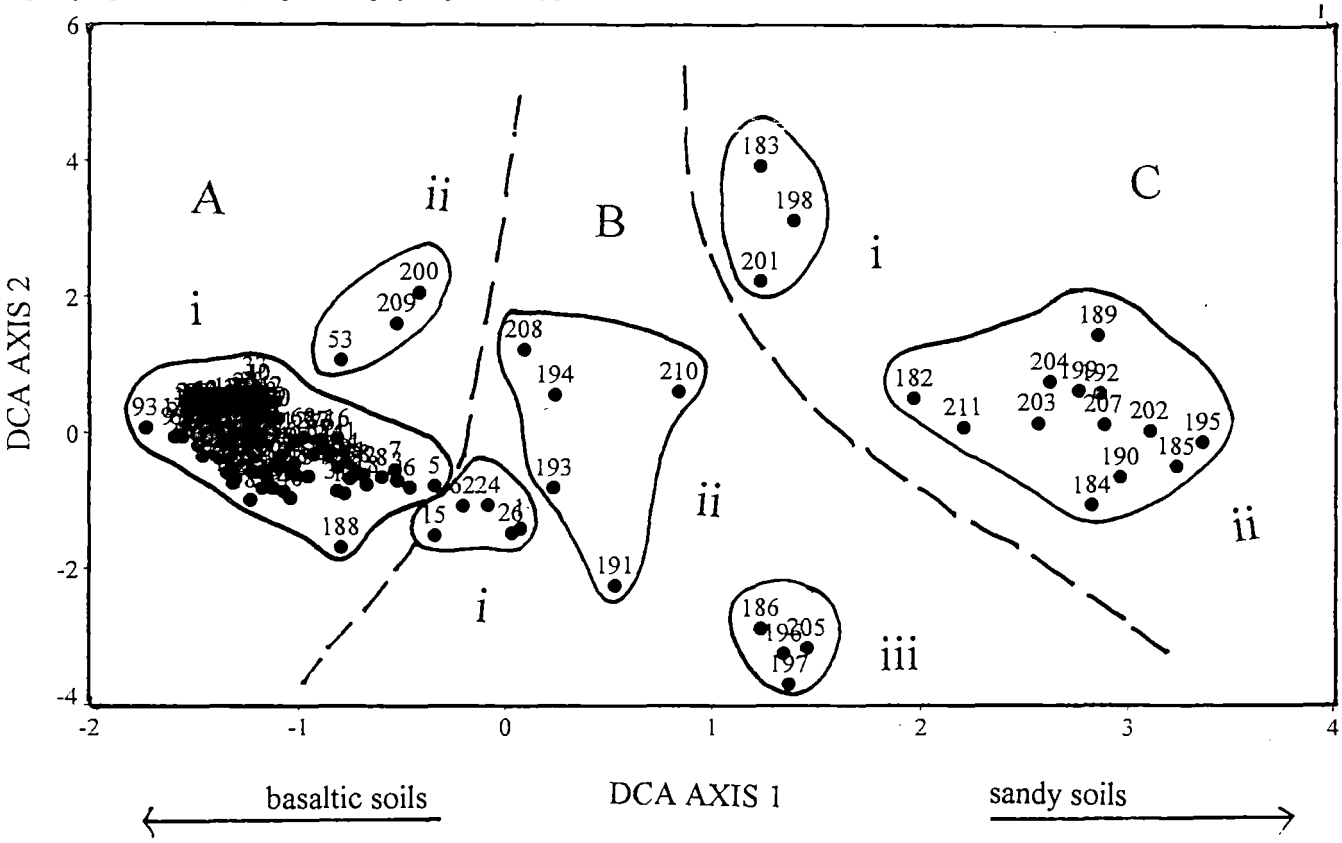
islands to have a greater total species richness. Simple regression of mean species richness against distance from the mainland (measure of isolation) did not indicate a significant relationship. Only 15.9% of the variation was accounted for by isolation. Regression of island species richness on area of island was also not significant with only 14.8 % of the variation being accounted for.

Ordination

The distribution of the stands along the first and second axes of a DCA scatter diagram is presented in Figure 2. Ordination by DCA of the species data indicated that 75.2% of the variation was accounted for by axis 1, while axes 2, 3 and 4 accounted for 55%, 40% and 30.8%, respectively. In the scatter diagram distinct grouping of plots along axis 1 can be observed. These groupings (A, B, C) represent physiognomic types but patterns reflecting groupings based on floristic dominance are also apparent.

Group A comprises woodland types but some of the shrublands are also found in this group. Two main clusters are evident within the group. One of the clusters (A (i)) contains woodland samples, the majority of which were from Sibilobilo area (Basin 4). The other cluster (A (ii)) comprises a few woodland samples from the western parts of the study area.

Group B is composed of plots of grasslands. The plots are largely scattered but some pattern in clustering is apparent with three main clusters. The first cluster (B(i)) comprises grassland plots in which *Aristida* species were an important component or dominant. The second cluster (B(ii)) comprises scattered plots of varying species dominance but mostly where the woody component was significant. The third cluster (B (iii)) is largely composed of plots in which *Melinis repens* and



Physiognomic Type

A Woodlands & shrublands
B Grasslands
C Thickets, woodland thickets and shrublands

Figure 2: Ordination diagram resulting from Detrended Correspondence Analysis of 211 vegetation stands

Panicum repens, were dominant or co-dominant.

Group C is composed of plots from thickets, woodland thickets and some shrublands. Two main clusters can be recognised. Cluster C(i) is composed of three plots of shrubland while the rest of the plots in cluster C(ii) comprise thickets and woodland thickets with various dominant species.

A gradient in soil type is illustrated along the first axis. Communities situated to the left of the diagram are found on basaltic and clayey soils in Basins 4 and 5 while those to the right are associated with sandy soils and Kalahari sands. No environmental gradient could be identified along the second axis.

Vegetation classification

The vegetation of Lake Kariba islands and the adjacent mainland has been classified into twenty-six types. The types are from forty-six islands surveyed in basins 2 to 5.

Woodlands

Colophospermum mopane woodland (Type 1)

This vegetation type consists of a well developed *Colophospermum mopane* woodland, with *Colophospermum mopane* trees up to 10 m high and cover abundance of over 50%. *Combretum elaeagnoides* is the most dominant and abundant species in the shrub layer. This vegetation type has a diverse range of other common shrub species, the dominant being *Grewia flavescens*, *Terminalia prunioides*, *Diospyros quiloensis* and *Terminalia stulhmanii.* There is a well developed herbaceous layer with *Hibiscus micranthus, Desmodium ospriostreblum, Indigofera trita* var. *sibula* and *Sida cordifolia* common. This vegetation type is species-rich, with an average of 47 species recorded on Mbeta island. There is a well developed grass layer which is dominated by *Panicum maximum, Melinis repens* and *Brachiaria deflexa.* This type is found on coarse loamy sands and on medium to coarse sandy loams, on Tsetse, Pimple, Antelope, Zebra, Redcliff, Marker, Mbeta and Tower islands. It also occurs along the shoreline adjacent to Sijarira Forest land and Sinamwenda mainland.

Colophospermum mopane-Combretum apiculatum woodland (Type 2)

This vegetation type occurs mainly as a woodland but sometimes as a shrubland dominated by *Colophospermum mopane* and *Combretum apiculatum.* Woody species dominance sometimes shifts from a co-dominance of *Colophospermum mopane* and *Combretum apiculatum* to single dominance of either of the two. This is a common vegetation type on the islands. It is the most extensive vegetation type on islands within the Sibilobilo area and in Sanyati basin. It can be divided into two sub-types based mainly on the dominant grass species. One subtype is dominated by *Aristida adscensionis* and the other is dominated by *Andropogon sp.* in the grass layer.

Subtype 2.1

This is a woodland dominated by *Colophospermum mopane.* It has a well developed shrub layer of up to 3 m high with a diverse range of species. Common shrubs are *Combretum apiculatum, Erythroxylum zambesiacum, Pseudolachnostylis maprouneifolia, Ximenia caffra* and *Ormocarpum kirkii.* There is a relatively species-rich herbaceous layer with *Sida alba, Indigofera schimperi, Aristolochia alba* and *Indigofera astragalina* dominant. The grass layer is well developed and is dominated by *Aristida adscensionis* with cover abundance of up to 50%. *Aristida adscensionis* usually occurs with *Heteropogon contortus, Setaria pumila, Melinis repens* and *Perotis patens.* Grasses are up to 1 m high. This sub-type is heavily browsed by elephants. Browsing is particularly heavy on *Colophospermum mopane* and *Combretum apiculatum.* Some trees have been pushed over, thus this vegetation type is gradually being changed into a shrubland. It occurs on Namembere, Namagwaba, Balabi, Lubangwa, 126, 127, Chasayi, Nandavwi, Kampaka and P *and* Q islands. This type is also found on Sampakaruma group, 123, 124, 110, Weather, Zebra, Antelope, 40 mile and 49 islands. It occurs on a wide range of shallow soils ranging from fine to coarse sand clay loams, clay soils, fine to medium sandy loams, clay loams, coarse sandy clay and medium loamy sands. This type also occurs along the shoreline area adjacent to Sengwe Peninsula on the mainland, Sinamwenda mainland and along Omay mainland between Sibilobilo Fishing Camp and Chalala lagoon. Near the shoreline the type is more mixed. *Colophospermum mopane* becomes dominant further inland. There is apparent evidence of damage by elephants and in some places *Karomia tettensis* and *Diospyros quiloensis* dominate the shrublayer.

Subtype 2.2

This vegetation type is a low woodland that is distinguished from subtype 2.1 by the dominance of *Andropogon* sp. in the grass layer. There are few trees more than 6 m high. It is composed mainly of shrubs less than 3 m high. *Colophospermum mopane, Combretum apiculatum* and *Commiphora glandulosa* have been heavily browsed by elephants. Associated shrubs include *Erythroxylum zambesiacum, Diospyros kirkii, Afzelia quanzensis, Terminalia stenostachya* and *Terminalia sericea.* Other shrubs include *Dalbergia melanoxylon, Turraea nilotica* and *Catunaregum spinosa.* The herbaceous layer has *Hibiscus micranthus, Indigofera astragalina* and *Indigofera schimperi* dominant. The grass layer is dominated by tall grasses of *Andropogon* sp. which are up to 1.5 m high. Other grass species which occur in this type are *Heteropogon contortus, Melinis repens, Aristida adscencionis, Panicum maximum* and *Loudetia simplex.*This type is

found on shallow soils, with boulders and pebbles on the surface. It occurs on 123, 124, P, Patridge, 110, Namagwaba and Namembere islands. It occurs on a wide range of soil types including clays, medium sandy loams, medium loamy sands, fine sandy clay loams and fine sandy clays.

Colophospermum mopane mixed woodland (Type 3)

This vegetation type is a mixed woodland with varied species composition, but sometimes dominated by *Colophospermum mopane* and *Afzelia quanzensis*. Typical tree species include *Colophospermum mopane*, *Combretum elaeagnoides*, *Combretum apiculatum*, *Commiphora mossambicensis* and *Afzelia quanzensis*. Sometimes an occasional shift in dominance between *Colophospermum mopane* and *Afzelia quanzensis* occurs. On karoo soils derived from sandstone *Colophospermum mopane* is found in association with *Terminalia stuhlmanii* and *Commiphora africana* and on clayey soils *Colophospermum mopane* becomes dominant. This reflects a localised switch in dominance due to soil differences. The shrub layer is well developed and consists of *Karomia tettensis*, *Markhamia zanzibarica*, *Erythroxylum zambesiacum*, *Diospyros quiloensis* and *Dalbergia martinii*. The herbaceous layer is dominated by *Tephrosia purpurea*, *Sida alba*, *Commellina benghalensis* and *Justicia kirkiana*. There is a good grass cover with *Panicum maximum*, *Heteropogon contortus* and *Melinis repens* dominant. This type is found on the mid-slope to top of Chasayi and Mambaleza islands. It occurs on coarse sand, sandy loams and loamy sands. It also occurs on Nandavwi island on the steep mid-slope to the top of the island where there are tall, mature and well developed *Colophospermum mopane* trees. There is no evidence of elephant damage.The island is inaccessible to elephants since they are prevented from moving into the lake by the owner of the adjacent Sijarira Safari Area. The trees are therefore well preserved.

Combretum apiculatum mixed woodland (Type 4)

This type is a mixed woodland, with variable species composition. *Combretum apiculatum* usually assumes dominance, with cover abundance up to 50%. Typical species are *Combretum apiculatum*, *Colophospermum mopane*, *Diospyros quiloensis*, *Pteliospis myrtifolia*, *Afzelia quanzensis* and *Albizia harveyi*. There is a well developed middle layer dominated by *Karomia tettensis*, *Carphalea pubescens*, *Grewia monticola* and *Erythroxylum zambesiacum*. This type is typically represented on 40-mile island in Sibilobilo area. Species that occur in the herbaceous layer include *Blepharis maderaspatensis*, *Spermacoce chaetocephala*, *Justicia kirkiana* and *Jacquemontia tamnifolia*. There is a high density of lianes mainly *Cissus grisea*, *Tacazzea apiculata*, *Stomatostemma monteroae*, *Fockea multiflora* and *Cissus welwitschii*. The grass layer is dominated by *Panicum* sp. Other grass species are *Dactyloctenium aegyptiacum*, *Melinis repens and Aristida adscenscionis*. This vegetation type occurs on medium sandy soils on 40-mile island and on deep fine sandy soils on Long and Sampakaruma islands.

Mixed *Combretum* spp. woodland (Type 5)

This type occurs as either a shrubland or woodland. The dominant shrubs are *Combretum* species mainly *Combretum zeyheri*, *Combretum elaeagnoides* and *Combretum apiculatum*. Other common shrubs are *Diospyros kirkii*, *Karomia tettensis*, *Crossopteryx febrifuga*, *Pseudolachnostylis maprouneifolia* and *Ximenia americana*. There is a well developed herbaceous layer with *Chamaecrista mimosoides*, *Striga gesnerioides* and *Calostephane divaricata* dominant. The grass layer is well developed with *Heteropogon contortus* and *Loudetia simplex* dominant. Other common grass species are *Panicum heterostachyum*, *Setaria pumila*, *Melinis repens*, *Perotis patens* and *Aristida adscensionis*. This type is found on Chasayi island on deep coarse sands. It also occurs along the shoreline adjacent to Kariba town on sandy clay loams (Mica point area). *Combretum apiculatum* becomes more dominant further inland.

Combretum elaeagnoides mixed woodland (Type 6)

This is a mixed woodland to a mixed shrubland with *Combretum elaeagnoides* sometimes assuming-dominance, with cover abundance up to 75%. Typical tree species include *Combretum elaeagnoides, Commiphora africana, Afzelia quanzensis* and *Triplochiton zambesiacus*. Other species include *Diospyros quiloensis, Combretum apiculatum, Colophospermum mopane, Carphalea pubescens* and *Karomia tettensis*. *Carphalea pubescens* and *Karomia tettensis* sometimes form thickets in the shrub layer. There is a well developed herbaceous layer with *Tephrosia purpurea, Tephrosia euprepes, Justicia kirkiana* dominant. The grass layer is well developed with mixed grass species including *Setaria pumila, Alloteropsis cimicina, Panicum heterostachyum* and *Aristida adscensionis*. Other grasses found are *Leptocarydion vulpiastrum, Eragrostis rogersii* and *Melinis repens*. The grasses are generally very tall, up to 2 m high. This vegetation type occurs on Kampaka, Samunomba, Masuko, 49 and Diamond islands. It is also found along the shoreline adjacent to Sijarira Forest land and Sinamwenda Sounds. It occurs on sandy loams and on medium to coarse loamy sands.

Julbernardia globiflora woodland (Type 7)

This vegetation type is dominated by tall *Julbernardia globiflora* trees which are up to 12 m high, with *Combretum apiculatum* and *Combretum zeyheri* common. Associated tree species include *Diospyros quiloensis, Combretum mossambicensis, Karomia tettensis, Sclerocarya birrea, Terminalia sericea* and *Burkea africana*. The herbaceous layer is dominated by *Sida cordifolia, Tephrosia purpurea, Indigofera*

inhambanensis and *Justicia kirkiana*. There is a well developed grass layer with *Perotis patens*, *Pogonarthria squarrosa*, *Panicum heterostachyum* and *Melinis kallimorpha* dominant. Other grasses found are *Eragrostis ciliaris* and *Panicum maximum*. This vegetation type occurs along the shoreline adjacent to Chete mainland on deep sandy soils. Further into the mainland *Julbernardia globiflora* becomes more dominant. It is the dominant vegetation type in Chete Safari Area.

Ficus sycomorus woodland (Type 8)

This vegetation type is only found on a small island near Masuntu island in Binga area. It has tall *Ficus sycomorus* trees which are 8-10 m high and is the only tree species in this type. The island is usually almost completely covered by water during high water, except for the peak. It has a very steep terrain.There are rocks and boulders covering over 80% of the surface and there is hardly any soil. Plants grow from crevices. Common herbaceous species include *Amaranthus hybridus*, *Solanum nigrum*, and a climber *Ctenolepsis cerasiformis*. Other herbaceous species that occur in this type are *Elachyptera parvifolia*, *Sida alba*, *Indigofera tinctoria* var. *arcuata*, *Rhynchosia minima*, *Boscia salicifolia* and *Achyranthes aspera* var. *sicula*. There is a poor grass cover with *Echinochloa colona*, *Dactyloctenium aegyptium* and *Brachiaria deflexa* dominant.

Acacia nilotica woodland (Type 9)

This is a secondary vegetation type which is dominated and characterized by scattered *Acacia nilotica* trees, up to 6 m high. Sometimes *Acacia nilotica* co-dominates with *Dichrostachys cinerea*. This type was a previous grass community which has been successfuly invaded and colonized by Acacia. *nilotica*. The area was previously cultivated (Siyasai, pers. comm.) probably resulting in the invasion of Acacia. *nilotica*. Other shrubs found in this type are *Grewia monticola* and *Colophospermum mopane*. It has a dense species-rich herbaceous layer with *Indigofera tinctoria* dominant. The grass layer is well developed and common grasses are *Melinis repens*, *Panicum maximum* and *Eragrostis viscosa*. This type occurs on medium sandy loams on Samunomba, Tsetse and Mubende islands.

Acacia nigrescens-Afzelia quanzensis mixed woodland (Type 10)

This vegetation type is well-defined on Snake Island. It is quite different from the rest of the other types mainly due to the soil type and the relatively sharp rise in terrain. There is a mixture of trees with different ecological affinities ranging from those favouring mesic conditions to those that can tolerate low moisture levels. Common species are *Acacia nigrescens*, *Afzelia quanzensis*, *Combretum mossambicensis*, *Terminalia sericea* and *Markhamia zanzibarica*. The shrub layer consists of *Grewia flavescens*, *Turraea nilotica*, *Catunaregum spinosa* and *Commiphora glandulosa*. Other shrubs include *Commiphora karibensis*, *Olax dissitiflora*, *Pseudolachnostylis maprouneifolia* and *Ormocarpum kirkii*. There are localised thickets of *Grewia* species and *Catunaregum spinosa*. Isolated shrubs of *Calotropis procera* occur towards the edges of the type. There is a well developed grass layer with tall grasses dominated by *Panicum maximum*, with *Panicum repens* and *Phragmites mauritianus* confined near the water edge. This vegetation type is relatively pristine and is found on coarse to medium sandy loams.

Thickets and woodland thickets

Karomia tettensis thicket (Type 11)

This vegetation type is dominated by *Karomia tettensis*, with cover abundance ranging from 50%-75%. It arises from over-utilisation and degradation of *Colophospermum mopane* woodlands by large herbivores, particularly elephants. Sometimes *Karomia tettensis* co-dominates with *Combretum elaeagnoides* and *Combretum apiculatum*. A transitional process of degradation marked with differences in species dominance is envisaged; starting with *Colophospermum mopane-Combretum apiculatum* woodland to *Combretum apiculatum-Karomia tettensis* shrubland leading to a *Karomia tettensis* thicket. In the second transitional stage the dominant species are *Karomia tettensis*, *Combretum elaeagnoides*, *Combretum apiculatum*, *Combretum zeyheri* and sometimes *Diospyros quiloensis*. This transitional vegetation type has a high species diversity. Other species found include *Erythroxylum zambesiacum*, *Lonchocarpus eriocalyx* subsp. *wankiensis*, *Vangueria infausta* and *Commiphora mossambicensis*. Thickets of almost pure stands of *Karomia tettensis* are species-poor and impenetrable. Few emergent *Colophospermum mopane* trees occur. The herbaceous layer is well developed and species-rich. Species include *Cardiospermum halicacabum* var. *microcarpum*, *Tarrena luteola*, *Hibiscus rhabdotospermus*, and *Crotalaria reptans*.There is a well developed grass layer with *Panicum maximum*, *Panicum heterostachyum* and *Setaria pumila* common. This is found on coarse loamy sands and on coarse to medium sandy loams on the mid-slopes to tops of islands. This vegetation type is common on Nandavwi, Masuko, Mbeta, Petrol, Namembere, Patridge, R, Mbeta and on Elephant islands and is also found along the shoreline adjacent to Sinamwenda mainland. It is heavily browsed by elephants.

Diospyros quiloensis thicket (Type 12)

This vegetation type, dominated by *Diospyros quiloensis* assumming almost 100% cover, also arises as a result of heavy utilization by large herbivores. There are multi-stemmed *Diospyros quiloensis* shrubs and a few trees. Two other species that occur in this type are *Combretum elaeagnoides* and *Sida cordifolia*, the latter dominating the shrub layer. Other shrubs sometimes found in this type include *Colophospermum mopane*, *Karomia*

tettensis and *Combretum apiculatum.* The grass layer is dominated by *Eragrostis viscosa* and *Perotis patens.* This vegetation type is found on Starvation island and along the shoreline adjacent to Bumi mainland just close to Starvation island. Along the shoreline the grass layer is dominated by *Eragrostis ciliaris* and *Aristida adscenscionis.*

Combretum celastroides woodland thicket (Type 13)

This vegetation type is a woodland thicket characterized by a well developed shrub layer dominated by *Combretum celastroides* with cover abundance ranging from 60-75%. Occasional open patches occur but it is mainly a dense woodland thicket. Sometimes *Karomia tettensis* becomes co-dominant, forming impenetrable thickets in the shrub layer. There are a few emergent *Colophospermum mopane, Adansonia digitata, Pteliopsis myrtifolia* and *Sclerocarya birrea* trees indicating relics of the previous vegetation type. All shrubs are less than 3 m high being maintained by constant browsing by elephants. Other shrubs found in this type are *Lonchocarpus eriocalyx* subsp. *wankieensis, Markhamia zanzibarica, Erythroxylum zambesiacum* and *Terminalia prunioides.* There is a well developed dense herbaceous layer with *Indigofera tinctoria* and *Siphonochilus kirkii* dominant. *Indigofera tinctoria* and *Waltheria indica* sometimes assume dominance in the herbaceous layer, with total cover abundance up to 40% and are up to 3 m high. The grass layer is well developed. Dominant species are *Setaria sphacelata, Panicum maximum* and *Urochloa trichopus.* Other associated grass species are *Panicum heterostachyum, Setaria pumila, Eragrostis viscosa, Melinis repens* and *Leptocarydion vulpiastrum.* This vegetation type is common on all islands within Sinamwenda area; Christmas, Elephant and Zinyama islands in Binga. It occurs on a wide range of sandy soils with variable textures; coarse sands, coarse and medium loamy sands and coarse to medium sandy loams. The structure of this type has been influenced by elephant browsing.

Guibourtia conjugata woodland thicket (Type 14)

This type is dominated by *Guibourtia conjugata* and occurs either as a woodland or woodland thicket. *Meiostemon tetrandrus,Combretum celastroides* and *Karomia tettensis* dominate the shrub layer and form an impassable thicket of up to 3 m high. Sometimes *Combretum elaeagnoides* becomes co-dominant. Other dominant shrubs in the middle layer are *Combretum zeyheri* and *Pteliopsis myrtifolia.* Common associated shrubs mainly found on loamy sands and sandy clay loams are *Crossopteryx febrifuga, Pseudolachnostylis maprouneifolia* and *Lonchocarpus eriocalyx* subsp. *wankieensis.* On coarse sands, common shrubs are *Carphalea pubescens, Acacia eriocarpa, Dalbergia martinii, Dalbergia melanoxylon, Vitex payos, Manilkara mochisia and Commiphora africana.*The herbaceous layer comprises *Amorphophallus abyssinicus, Indigofera setiflora* and *Jacquemontia tamnifolia.* There is a well developed grass layer with *Setaria pumila,* tufts of *Loudetia simplex, Panicum heterostachyum, Brachiaria deflexa* and *Panicum maximum* dominant. This vegetation type is found on the mid-slopes to the tops of Nandavwi and Mambaleza islands. On Mambaleza island it occurs on coarse sands where well developed *Guibourtia conjugata* trees are found with *Karomia tettensis* forming a thicket in the shrub layer. *Commelina benghalensis* dominates the herbaceous layer with cover abundance of up to 75% and 1 m tall. On coarse loamy sands to coarse sandy clay loams *Combretum zeyheri, Combretum elaeagnoides* and *Meiostemon tetrandrus* subsp. *australis* dominate the shrub layer. This vegetation type is also found along the shoreline adjacent to Sijarira Forest Land on the mainland on deep sandy loams.

Shrublands

Colophospermum mopane shrubland (Type 15)

This type is a degraded form of *Colophospermum mopane* woodland (Type 1). It is a shrubland dominated by shrubs of *Colophospermum mopane* of less than 3 m in height. *Colophospermum mopane* trees have been heavily and extensively damaged by elephants. They are now multi-stemmed and stunted. Constant browsing by elephants is maintaining this type in the current state. Associated shrubs are *Terminalia stulhmanii, Erythroxylum zambesiacum, Markhamia zanzibarica* and *Combretum elaeagnoides.* Other shrubs found in this vegetation type are *Croton manyhartii, Croton gratissimus, Maerua decumbens, Boscia matabelensis, Barleria proonitis* subsp. *ameliae* and *Barleria taitensis.* Common species in the herbaceous layer include *Sida cordifolia, Indigofera schimperi* and *Indigofera astragalina.* There is a well developed grass layer dominated by *Urochloa trichopus, Aristida rhiniochloa* and *Brachiaria deflexa.* This vegetation type is common along the shoreline areas adjacent to Sinamwenda and along Chete mainland areas. Futher inland this type changes to *Colophospermum mopane* woodland (Type 1).

Mundulea sericea shrubland (Type 16)

This type is a localised shrubland dominated by *Mundulea sericea* with cover-abundance of over 50%. Associated shrubs are *Lonchocarpus eriocalyx* subsp. *wankieensis, Combretum apiculatum, Pteliopsis myrtifolia, Sclerocarya birrea* and *Combretum apiculatum.* A few emergent trees of *Sclerocarya birrea* and *Pteliopsis myrtifolia* occur. This is a very small community that is confined to the peak of Rhino island. It occurs on very shallow soils where the surface is covered with rocks and boulders resulting in a poor grass cover with short grasses of *Melinis repens* and a poor herbaceous layer with *Tridax procumbens* and

Taccazzea apiculata.

Croton menyhartii shrubland (Type 17)

This is a shrubland dominated by *Croton manyhartii.* There is a wide range of shrubs the dominant being *Gardenia resiniflua* and *Acacia ataxacantha.* The grass layer is well developed the dominant grass being *Panicum maximum.* This is a secondary vegetation type, the original community of *Colophospermum mopane* woodland having been heavily disturbed in the past.There are a few emergent *Colophospermum mopane, Afzelia quanzensis* and *Adansonia digitata* trees, relics of the previous type. This type is found on Zebra island on shallow coarse sandy clay loams and on Sinamwenda mainland where *Colophospermum mopane* is heavily degraded.

Pteliopsis myrtifolia shrubland (Type 18)

This type is mainly a shrubland but sometimes occurs as a woodland thicket. It is dominated by *Pteliopsis myrtifolia* with *Meiostemon tetrandrus* and *Karomia tettensis* sometimes becoming dominant, the latter forming thickets in some places. Sometimes a switch in dominance occurs from *Pteliopsis myrtifolia* to *Meiostemon tetrandrus.* This vegetation type is species-rich, with up to 61 species recorded at one site. There are a few emergent *Colophospermum mopane, Adansonia digitata* and *Kirkia acuminata* trees. There is a wide range of shrubs including *Carphalea pubescens, Commiphora glandulosa, Lonchocarpus eriocalyx* subsp. *wankieensis* and *Pterocarpus antunesii.* Species found in the herbaceous layer are *Hibiscus rhabdotospermum, Hibiscus micranthus* and *Fockea multiflora.* The grass layer is generally well developed although less dense patches sometimes occur. Dominant grass species are *Panicum maximum, Dactyloctenium aegyptium, Setaria pumila* and *Brachiaria deflexa.* In less dense patches *Eragrostis viscosa* is dominant. This vegetation type is found on Kudu, Elephant, Marker, Masuko, Kangamani, Mubenda and Masuntu islands. It also occurs along the shoreline adjacent to Sinamwenda mainland where *Meiostemon tetrandrus* forms dense thickets with occassional shrubs of *Colophospermum mopane* and *Pteliopsis myrtifolia.* It occurs on coarse sands and coarse loamy sands from the mid-slope to the top of the island.

Indigofera tinctoria shrubland (Type 19)

This type is a shrubland that is dominated by the legume *Indigofera tinctoria* which sometimes assumes total dominance and is up to 3 m high. It is a secondary vegetation type; a former grassland that has been invaded by *Indigofera tinctoria.* It occurs on the bottom slopes of the islands where the grasses *Melinis repens, Urochloa trichopus* and *Panicum repens* co-dominate. Occassional shrubs of *Colophospermum mopane, Kirkia acuminata* and *Lonchocarpus eriocalyx* usually occur. The herbaceous layer is dominated by legumes including *Tephrosia purpurea, Tephrosia euprepes, Indigofera colutea, Indigofera nummulariifolia* and *Indigofera strobilifera* subsp. *strobilifera.* This type is common on islands in Sinamwenda and Binga. It occurs on Mambaleza, Mbeta, Diamond, Kangamani, Christmas, Termite, Garden, Elephant, Tower and Marker islands. It occurs on a wide range of soil types; coarse sandy soils, coarse loamy sands and medium to coarse sandy loams.

Grasslands

Melinis repens wooded grassland (Type 20)

This vegetation type is a wooded grassland which is common on most of the islands surveyed. It is dominated by *Melinis repens* with cover abundance of up to 75% and *Aristida adscenscionis.* Within this type there are shrubs of *Colophospermum mopane, Grewia bicolor, Terminalia stuhlmannii* and *Mundulea sericea* scattered in the grassland. On Redcliff, Antelope and Tsetse islands localised dense clumps of *Dichrostachys cinerea* and *Acacia nilotica* occur. The encroachment of *Acacia nilotica* and *Dichrostachys cinerea* is expanding as a response to overgrazing by buffalos, elephants and impala. Sometimes well established stands of *Dichrostachys cinerea* form thickets. *Calotropis procera* is also gradually encroaching in this type, although it is still found as few isolated shrubs. Associated grass species are *Eragrostis viscosa, Panicum repens* and *Panicum maximum.* Herbaceous species include *Rhynchosia minima* var. *minima, Tephrosia purpurea, Indigofera tinctoria* and *Indigofera setiflora.* This type is found on coarse sands and coarse to medium sandy clay loams on the bottom slopes of Rhino, Kangamani, Nandavwi, Sampakaruma, Mubende, Samunomba and Masuko islands. It is also found on islands 110 and 124 in Sibilobilo area on medium sandy loams and medium loamy sands. In Sibilobilo area there are fewer herbaceous species, the dominant ones being *Rhynchosia sublobata* and *Indigofera astragalina.* Soils where this type is found are generally shallow, and in some places much of the ground surface is covered by rocks and boulders. *Melinis repens* grassland also occurs along the shoreline adjacent to Sengwe inlet on the mainland and on mainland adjacent to Sijarira Forest Land and Binga mainland. Along the shoreline the grass is short probably because of shallow soils. The herbaceous layer is largely absent along the shoreline but there are shrubs of *Elephantorrhiza goetzei, Kirkia acuminata, Colophospermum mopane* and *Diospyros quiloensis.*

Panicum repens grassland (Type 21)

This grassland is dominated by low swards of *Panicum repens* with cover-abundance ranging from 50-100% and height from 0.5 m in heavily grazed areas; to 1m in less disturbed areas. Other grasses found in this type include *Andropogon eucomus, Eragrostis viscosa, Melinis repens, Pogonarthria squarrosa* and sedges *Cyperus articulatus* and *Bulbostylis* sp. Small shrubs of *Mundulea sericea, Colophospermum mopane, Ziziphus mucronata* and *Mimosa pigra* are occassionaly found.

Dense localised clumps of *Phragmites mauritianus* and *Sesbania sesban* also occur within the grassland at the bottom of the slope close to water. There is a well developed herbaceous layer and the species in that layer include *Indigofera astragalina, Indigofera gairdneri, Indigofera tinctoria* and *Rhynchosia minima.* This vegetation type resulted from the formation of Lake Kariba and is confined to the bottom slopes of most of the islands near the water edge. This is where buffaloes spend much of their time grazing. It is found on coarse sandy soils and sometimes grows from crevices when the surface is covered by rocks and boulders. It is found on Christmas, Starvation, Marker, Long, Nandavwi and Snake islands on fine sandy soils. It is also found along the shoreline adjacent to Kudu island on sandy soils.

Aristida rhiniochloa grassland (Type 22)

This is a localised grassland and is dominated by *Aristida rhiniochloa.* The only other grass species is *Melinis repens.* Shrubs of up to 3 m of *Colophospermum mopane, Calotropis procera* and *Dichrostachys cinerea* also occur in this type. The dominant herbaceous species is *Tephrosia purpurea.* This type is found on Antelope island and Redcliff island on shallow soils covered with rocks and pebbles.

Aristida adscensionis grassland (Type 23)

This is a grassland dominated by *Aristida adscensionis.* Associated grass species include *Heteropogon contortus, Aristida congesta* and *Melinis repens. Panicum repens* sometimes co-dominates although it is confined to areas near the water edge. The herbaceous layer comprises a few individuals of *Indigofera schimperi* and *Tephrosia purpurea.* Sometimes shrubs of *Mundulea sericea, Colophospermum mopane* and *Flueggia virosa* are found. This is the most extensive grassland type on islands within the Sibilobilo area; Namagwaba, Namembere, Lubangwa, 40 mile, Weather and Patridge islands. This type is also found along the shoreline adjacent to Omay mainland. Along the shoreline grasses are short and there is no herbaceous layer, only a few shrubs of *Colophospermum mopane, Acacia nilotica* and *Tephrosia purpurea* occur. It occurs on clay soils, fine to medium sand clay loams, medium sands and on fine loam sands. Soils where this type occurs are generally shallow with boulders, stones and pebbles on the surface.

Heteropogon contortus grassland (Type 24)

This vegetation type is dominated by *Heteropogon contortus* sometimes co-dominating with *Melinis repens.* Other grasses found in this type are *Aristida rhiniochloa, Schmidtia pappophoroides, Bothriochloa bladhii, Melinis repens* and *Eragrostis rotifer.* The grasses are short, up to 0.5 m high. Occassional shrubs of *Acacia nilotica, Pseudolachnostylis maprouneifolia, Colophospermum mopane* and *Combretum mossambicensis* occur. There is a well developed herbaceous layer with *Indigofera astragalina, Crotalaria virgulata* and *Tephrosia purpurea* dominant. This vegetation type is found along the shoreline adjacent to Omay communal land between Sibilobilo Fishing Camp and Chalala lagoon, Mica point mainland (near Kariba town) and along Nyanyana area. Soils where this vegetation type is found are shallow with boulders and pebbles on the surface .

Urochloa trichopus wooded grassland (Type 25)

This is a wooded grassland with *Urochloa trichopus* dominant. This type has been extensively and heavily invaded by *Indigofera tinctoria.* Other grass species include *Echinochhloa colona, Sporobolus pyramidalis* and *Panicum maximum.* It has a diverse and species-rich herbaceous layer with up to 22 species recorded in some places. Common herbaceous species include *Tephrosia euprepes, Tephrosia purpurea, Indigofera colutea* and *Waltheria indica.* Shrubs of less than 2 m high of *Terminalia prunioides, Mundulea sericea, Acacia tortilis* and *Erythroxylum zambesiacum* sometimes occur. This type is found on the bottom slopes of Christmas and Termite islands in Sinamwenda area, on medium sandy loams to medium loamy sands.

Eragrostis viscosa wooded grassland (Type 26)

This vegetation type is dominated by *Eragrostis viscosa.* Associated grass species include *Cynodon dactylon, Setaria sphacelata, Melinis repens* and *Panicum maximum.* The dominant woody species is *Sida cordifolia.* Species found in the herbaceous layer include *Indigofera tinctoria, Indigofera setiflora* and *Indigofera inhambanensis.* This vegetation type is found along the shorelines adjacent to Chete mainland on fine sandy loams and is restricted in distribution.

Discussion

Ordination

Detrended Correspondence Analysis grouped the plots according to their physiognomy and, to a lesser extent, floristic dominance. In some cases, different physiognomic types were grouped together such as woodlands and shrublands. Grasslands were clearly separated from the rest of the woody types. Apparent grouping of different physiognomic types together reflects a common occurrence of certain important or dominant species on these types irrespective of their physiognomy. *Colophospermum mopane* is an important dominant or co-dominant species in most woodlands and in some shrublands, hence these types are grouped together. Grasslands cluster C (i) is closer to the woodland types because the dominant grass genus, *Aristida,* is also a common dominant in the grass layer in the woodlands. The importance of this genus towards the western end of the study area becomes less as a number of other genera took over, resulting in those grassland plots from Sibilobilo area (basin 4) being grouped separately from the rest. The wide scatter among the rest of the grasslands plots indicates the lack of a common dominant grass species. In general, there

was a change in species dominance from east to west in the study area, hence the ordination technique gave a general trend where plots from the eastern areas occur on the left side of the diagram and those from the western parts on the right. This may imply that even though the dominant species in the vegetation types from the two respective parts of the study area described under one name were the same, the species composition of some of the strata tended to vary considerably.

Vegetation classification

The vegetation of Lake Kariba islands and adjacent mainland was classified into twenty-six types. Vegetation was classified according to species composition and structure. A catenary sequence was noticed on all islands surveyed. The grassland communities are confined to the bottom slopes between the water edge and the woodland types where the soil is moist since it is nearer the water edge. This is followed by woodland types either on the mid-slope or crests of islands.

Seven types of grasslands are described and these can be categorized into two main groups. Group 1 consists of near natural or grasslands that have not be invaded by leguminous plants (Types 21, 22, 23, 24, 26). The dominant grass species in this group are, *Panicum repens* (Type 21), *Aristida rhiniochloa* (Type 22), *Aristida adscensionis* (Type 23), *Heteropogon contortus* (Type 24) and *Eragrostis viscosa* (Type 26). The difference in species dominance is apparently determined by soil type. *Aristida adscensionis* occurs mainly on clayey soils, sandy clay loams, loamy sands and sometimes on medium sand. *Heteropogon contortus* and *Eragrostis viscosa* on fine sandy loams. *Panicum repens* dominates on fine to coarse sand, favours wetter soils and is confined to areas near the water edge. It thrives on moist sandy soils (Surrel 1987) and can withstand prolonged periods under water (McLachlan and McLachlan 1971) and is restricted more or less to the inundation zone on both the islands and along the mainland shoreline where it is constantly subjected to drought and inundation when the lake level rises and falls (Surrel 1987). Other grass species occur further up the bottom slope where it is less moist.

The second group consists of wooded grasslands that have been invaded by leguminous species due to overgrazing and degradation. Persistent overgrazing seem to lead to the encroachment of *Acacia nilotica, Indigofera tinctoria* and *Dichrostachys cinerea. Dichrostachys cinerea* is a persistent invader in overgrazed areas (Simpson 1975).

Woodland types are either disturbed on undisturbed. When undisturbed, well developed *Colophospermum mopane* woodland, *Colophospermum mopane-Combretum apiculatum* woodland, *Acacia nigrescens-Afzelia quanzensis* mixed woodland or *Combretum apiculatum* mixed woodland are found. Disturbed types consist of shrublands, thickets and woodland thickets.

Species dominance and richness seem to be influenced by soil characteristics, mainly soil type and depth. On basaltic soils in basins 4 and 5 the predominant vegetation type on the islands is dominated by either *Colophospermum mopane* or *Combretum apiculatum*. This varies in type from well developed *Colophospermum mopane* woodlands on heavy basaltic soils on islands in Sanyati basin (Zebra, Antelope and Tsetse) to degraded and stunted *Colophospermum mopane* shrubland. On these islands *Colophospermum mopane* is the dominant tree species and the woodlands are characterized by low species richness with a range of 3-10 species per plot, most of them being shrubs. According to Timberlake *et al.* (1993) this can be ascribed to the aggressive rooting habit of *Colophospermum mopane* with its well developed lateral root system which outcompetes most other species, and to the heavy texture of the soils on which it occurs. The soils are too dry and have high osmotic pressure such that there are physical difficulties of root penetration. When the soils crack during the dry season, the roots are sheared such that few plants can survive. The islands in Lake Kariba are generally rocky with large solid outcrops on high ground, which also probably makes it difficult to support other species of deeper rooting systems.

Most of the islands surveyed from Sinamwenda to Binga have sandy Karroo soils that are derived from the underlying sandstone. The soils are of variable texture and seem to influence vegetation type. *Combretum celastroides* woodland thicket and *Pteliopsis myrtifolia* shrubland occur on these soils. When undisturbed they are usually dry layered forests (Jesse bush) and are scattered across the Zambezi valley, generally on Karroo sediments at altitudes of 900 m or less (Timberlake *et al. 1993*). On the islands, elephants have caused major damage to this vegetation type, resulting in a change in vegetation structure, from an original dry layered thicket to dense shrubland thickets with a few emergents. Types 13 and 18 thus occur as woodland thickets with a few emergent trees. *Combretum celastroides,* which has a tendency to form thickets when disturbed, is the dominant shrub. *Meiostemon tetrandrus* a common dry thicket shrub, is also quite common. Well developed Jesse bushes are found on deeper sands. None of the islands surveyed supported an undisturbed Jesse bush. A similar type is found in the north and north west of Dande Communal Land and to the north of Dande Safari Area (Timberlake and Mapaure 1992) where it occurs as well-developed dry layered forests. In an undisturbed state, emergent trees of *Pteliopsis myrtifolia, Pterocarpus lucens* and *Entandrophragma caudatum* reach up to 18 m but most of these large trees on the islands were damaged by elephants. It appears that this type is prone to elephant damage resulting in its conversion to woodland thickets. Surveys elsewhere such as East Gokwe (Timberlake *et al.* 1993), Busi Sengwa (Muller and Timberlake 1992) and in Mana Pools National Park (Muller and Pope 1982) have indicated the same phenomenon.

The structure and species composition of Jesse bush is determined by the poor moisture retention in the sandy soils and the acidic subsoils, which result in a shallow rooting system of the majority of species in Jesse bush (Timberlake *et al.* 1993). Timberlake *et al.* (1993) suggest that when the shallow-rooted shrub layer becomes dominant, as on the islands, it prevents enough moisture infiltration through the surface layers. This results in deeper-rooted species being competitively disadvantaged, and hence such areas will remain as thickets unless subject to a very destructive fire which opens up and destroys the shrub layer.

Guibourtia conjugata woodland thicket on Nandavwi, Mambaleza islands and along the shoreline adjacent to Binga mainland is similar to Timberlake *et al.*'s (1993) Type C4 (*Guibourtia conjugata* woodland thicket). It represents the driest forest. This type was found on deeper coarse sand soils and also on coarse loamy sand to coarse clay loams. Tall slender trees of *Guibourtia conjugata* occur in the type and the shrub layer is dominated by *Meiostemon tetrandrus*, *Combretum celastroides*, *Combretum elaeagnoides* and *Pteliopsis myrtifolia*. Timberlake *et al.* (1993) recorded a similar type in North Binga, which is the mainland area adjacent to Nandavwi and Mambaleza islands. In Binga, *Guibourtia conjugata* thickets occupy slightly elevated areas on unconsolidated slightly coarse sand which probably originated from Karroo sandstone strata. It appears to be a relatively common vegetation type along the shoreline on the mainland adjacent to Nandawvi and Mambaleza islands. An intensive survey of the area will be required to determine the extent of cover as well as the status of the woodlands.

Terrain seems to influence the vegetation types on some of the islands. Snake island in Sibilobilo area supports an *Acacia nigrescens-Afzelia quanzensis* mixed woodland (Type 10) which is different from the rest of the vegetation types in the area. The island is conical, steep and is covered by boulders. There is poor substrate for plants to grow. The moisture retention capacity of the soil is therefore low. The type therefore supports a mixture of trees with different ecological affinities ranging from those favouring mesic conditions to those that can tolerate low moisture levels. This type is undisturbed since the island is relatively inaccessible to large herbivores. *Ficus sycomorus* woodland on an unnamed island near Masuntu island in Binga and *Mundulea sericea* shrubland on Rhino island also seem to be influenced by the terrain of the islands. The islands are rocky and probably present a hostile environment to plant growth.

Impacts of large herbivores

Large herbivores, especially elephants, are a major determinant of vegetation structure on the islands resulting in marked changes in structure and species composition. Overutilization by elephants has modified vegetation structure and has led to development of thickets dominated by one to two tree species. Vegetation types 11, 12, 13 and 18 are a result of heavy utilization by elephants and buffaloes. Due to increasing populations of large herbivores, especially elephants, vegetation structure has been changed from being predominantly *Colophospermum mopane* woodland (Type 1) or *Colophospermum mopane-Combretum apiculatum* woodland (Type 2) to either *Karomia tettensis* thicket (Type 11), *Diospyros quiloensis* woodland thicket (Type 12), *Combretum celastroides* woodland thicket (Type 13), *Colophospermum mopane* shrubland (Type 15) or *Pteliopsis myrtifolia* shrubland (Type 18). The difference in dominance among the types seem to be brought about by differences in soil properties.

The impact of herbivores is illustrated on Starvation island. Attwell and Bhika (1985) described the main vegetation type on Starvation island as being dominated by *Karomia tettensis*, *Combretum elaeagnoides*, *Combretum apiculatum* and *Diospyros quiloensis*. They, however, noted that there was heavy elephant damage. This study found that the former community has been modified and *Diospyros quiloensis* has assumed total dominance.

Elephants seem to feed selectively on *Colophospermum mopane* by either pushing it over, scarring or breaking branches and stems. Details on the patterns of elephant damage on *Colophospermum mopane* on selected islands in Lake Kariba are in Mapaure and Mhlanga (in prep) who found out that 50% of the *Colophospermum mopane* trees examined were damaged. Constant browsing and breaking of plants by elephants is trapping trees in the smaller height and girth classes. It has also been noted that compression of the elephant range may result in many small and medium-sized trees being knocked down, effectively forming a shrubland 1.5-2 m high (Timberlake 1995). We envisaged that after change of *Colophospermum mopane* woodland (Type 1) to a shrubland (Type 15), further degradation results in an increase in abundance of either *Karomia tettensis* or *Diospyros quiloensis*. *Karomia tettensis* is known to increase in response to disturbance (Timberlake *et al.* 1993).

There is a pattern along the shoreline which can be related to concentration of elephants along the shoreline across seasons. Three zones are distinguishable. Grasslands occur between the water edge and woodland vegetation types followed by an area which has been heavily impacted by elephants. In the second zone there is either *Colophospermum mopane* shrubland, *Diospyros quiloensis* woodland thicket, *Combretum celastroides* woodland thicket or *Karomia tettensis* woodland thicket. In the third zone there are tall mopane woodlands. Further inland there appears to be less damage. Large herbivores especially, elephants seem to spend most of their time in the second zone which is near water during the dry season (approximately 8 months per year). Within this zone the impact of elephants is gradually being noticed. Anderson (1973) and Anderson and Walker (1974) found some association between distance

to water and woodland damage. This can explain the pattern noticed in the present study. Buffaloes spend much of their time in the *Panicum repens* grassland.

Conservation and island biogeographic considerations

The islands in Lake Kariba presented an opportunity to test McArthur and Wilson's (1967) island biogeographic theory which attempts to explain species richness on an island on the basis of size and degree of isolation. A comparison was made between areas adjacent to the mainland and the islands. After analysis by DCA no clear patterns were noted in grouping of mainland and island plots. These would be expected to group separately if the species composition was significantly different for the adjacent plots on the respective sites. The only vegetation type found on the mainland which was not found on the islands is Type 7, *Julbernardia globiflora* woodland. Hence the vegetation types on the islands are largely similar in species composition to those on the adjacent mainland. The vegetation types have not changed significantly 29 years after isolation from the mainland. These findings show that the islands are still too young to show any differences in species composition due to isolation. Vegetation structure has, however, been influenced.

Due to their accessibility to animals from the mainland, the islands have effectively remained part of the mainland. The mean distance of most islands from the mainland is 1.5 km the furthest island is 9.9 km, which is close enough for birds, insects and elephants to influence dispersal of plant propagules across the two ecosystems. Toms (1978) noted that some of the insects he collected on Dinosaur island were not resident species but 'visitors' from adjacent islands or the mainland. This suggests a possible interaction between islands and the adjacent mainland. Despite being physically isolated by water, islands have not been totally secluded from the mainland and this has enabled constant interactions between the two ecosystems hence the islands have not followed their own course of biological development.

According to Muller and Timberlake (1992) botanical conservation can be based on two criteria. One approach focuses primarily on unusual, spectacular, rare or endemic species or areas of high species diversity and endemism. The other concentrates on the conservation of examples of all major vegetation types and ecosystems. The second criterion can be applied to conserve some of the vegetation types identified by the present study. None of the islands have vegetation types that are endemic or rare. Most of the vegetation types are well represented in the country. However, two islands Nandavwi and Mambaleza and the shoreline adjacent to Sijarira Forest Land have well developed *Guibourtia conjugata* woodland thickets which have not been disturbed. This vegetation type is of limited distribution in Zimbabwe, only being found in parts of Hwange District and Gonarezhou (Timberlake 1997). It is recommended that these two islands be preserved. There is need to carry out a more intensive survey on the adjacent shoreline to assess the extent of this vegetation type. Elephants do not access Nandavwi and Mambaleza islands, hence they are not threatened. The same vegetation type was identified in Binga District by Timberlake (1997). He however, noted that it has been extensively cleared for cultivation. These two islands can serve as ideal witness stands of the type.

Although no unique or rare vegetation types were found on any of the islands surveyed, it is still useful to preserve some of the islands as 'natural or field laboratories' for further study of ecological process and interactions with the mainland.

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References

Anderson, G. D. 1973. Vegetation composition and elephant damage in the major habitat types of the Sengwa Wildlife Research Area of Rhodesia. M.Sc. Thesis in Tropical Resource Ecology. University of Zimbabwe.

Anderson, G. D. and Walker, B.H. 1974. Vegetation composition and elephant damage in the Sengwa Wildlife Research Area, Rhodesia. Journal of the Southern African Wildlife Management Association. 4, 1-14.

Attwell, C.A.M. and Bhika, M. 1985. Feeding ecology of Impala on Starvation Island, Lake Kariba. South African Journal of Wildlife Research. 15 (2), 41-48.

Balon, E. K. and Coche, A. G. (eds) 1974. Lake Kariba: A man-made tropical ecosystem in Central Africa.

The Hague, Junk Publishers.

Bowmaker, A.P. 1973. An hydrobiological study of Mwenda River and its mouth, Lake Kariba Ph. D. Theses, University of Witwatersrand, Johannesburg.

Child, G. 1968. Behaviour of large mammals during the formation of Lake Kariba. Trustees of the National Museums of Rhodesia, Salisbury. 123 p.

Choate, T.S. 1975. Island populations and their role in wildlife conservation. Journal of South African Wildlife Management Association 5: 53-61.

Dyer, C. 1985. A preliminary survey of vegetation and soils of the Dinosaur Island, Lake Kariba. B.Sc. Thesis, Faculty of Science, Department of Botany, University of Witwatersrand.

Frost, P.G.H. (compiler) 1987. Damage to *Colophospermum mopane* in relation to elephant density at Kariba. A report of Working Group B (Animal Ecology), BZ2 Field Trip to Kariba, May 1987. University of Zimbabwe, Department of Biological Sciences.

Gauch, H.G. Jr. 1982. Multivariate analysis in Community Ecology. Cambridge University Press, Cambridge.

Lake Kariba Co-ordinating Committee 1960. Kariba Islands Survey. Roberts, Mullins *and*

Bannett Consulting Engineers, Salisbury; Zimbabwe. 120p.

Lake Kariba Fisheries Research Institute 1996. Lakeshore Combination Master Plan. Report of Study. Project Report No. 42. Zambia/ Zimbabwe SADC Fisheries Project. Prepared by the Technical Team. Kariba Lake Shore Master Plan Preparation Authority. Lake Kariba Fisheries Research Institute, Kariba, Zimbabwe.

Machena, C. 1989. Ecology of the hydrolittoral macrophyte communities in Lake Kariba, Zimbabwe. Ph.D. Thesis, Uppsala.

Magadza C.H.D. 1970. A preliminary survey of the vegetation of the shore of Lake Kariba. Kirkia. 7(2), 253-268.

Mapaure, I. and Mhlanga, L. (in prep). Patterns of elephant damage to *Colophospermum mopane* on selected islands in Lake Kariba, Zimbabwe and its management implications.

McArthur, R.H. and Wilson, E.O. 1967. The theory of island biogeography. Princeton. University Press. Princeton.

McLachlan, A.J. and McLachlan, S.M. 1971. Benthic fauna and sediments in the newly created Lake Kariba (Central Africa). Ecology. 52, 800-809.

Mitchell, D.S. 1970. Autecological studies of *Salvinia auriculata* Aubl. Ph. D. Thesis. University of London.

Mueller-Dombois, D. and Ellenberg, H. 1974. Aims and methods of vegetation ecology. John Wiley *and* Sons, New York.

Muller, T. and Pope, G. 1982. Vegetation report for the impact assessment of the proposed Mupata Gorge and Batoka dams on the Zambezi river. *In*: du Toit, R.F (ed.) A preliminary assessment of the environmental implications of the proposed Mupata and Batoka Hydro-electric Scheme (Zambezi River, Zimbabwe) pp 53-67. Natural Resources Board, Harare.

Muller, T. and Timberlake, J. 1992. Areas for plant conservation in Zimbabwe. Zimbabwe Science News. 26 (10/12), 88-95.

Simpson, C.D. 1975. A detailed vegetation study on the Chobe river in North-East Botswana. Kirkia. 10 (1), 185-217.

Schramm, E. 1978. A preliminary survey of the vegetation and distribution of the Loranthaceae of Dinosaur island (Island 126/127) Lake Kariba, Rhodesia. B.Sc. Dissertation. Faculty of Science, Department of Botany, University of the Witwatersrand.

Scudder T. 1962. The ecology of the Gwembe Tonga. Kariba Studies II (Manchester University Press), 1-274.

Skarpe, C. 1997. Ecology of the vegetation in the draw-down zone of Lake Kariba. *In*: Moreau, J. (ed.): Advances in the Ecology of Lake Kariba. University of Zimbabwe Publications, Mt. Pleasant, Harare.

Surrell, K. 1987. The shore types of Lake Kariba, Zimbabwe. A case study using Landsat MSS. Report from a minor field study. Working paper 47. Swedish University Of Agriculture. Uppsala.

Timberlake, J.R. 1995. *Colophospermum mopane*: Annotated bibliography and Review. The Zimbabwe Bulletin of Forestry Research No. 11. Forestry Commission, Harare, Zimbabwe.

Timberlake, J. 1997. Sites of interest for Botanical Conservation in the Communal Lands of the Zambezi Valley in Zimbabwe. Unpublished report. Zambezi Society, Harare, Zimbabwe.

Timberlake, J. and Mapaure, I. 1992. Vegetation and its conservation in the Eastern mid-Zambezi Valley, Zimbabwe. Transactions of the Zimbabwe Scientific Association. 66, 1-14.

Timberlake, J., Nobanda, N. and Mapaure, I. 1993. Vegetation survey of the Communal Lands: North and West of Zimbabwe. Kirkia, 14 (2), 171-272.

Toms, R. B. 1978. A preliminary qualitative study of the fauna and flora of an island ecosystem. Faculty of Science, Botany Department, University of the Witwatersrand.

Wild, H. and Barbosa, L.A.G. 1967. Vegetation map of the Flora Zambesiaca area. Supplement to Flora Zambesiaca. M.O. Collins, Harare.

White, F. 1965. The Savanna woodland of the Zambezian and Sudanian domains. Webbia 19: 651-681.

White, F. 1976. The vegetation map of Africa. The history of a completed project. Boissiera 24: 659-666.

Appendices

Appendix 1. List of vegetation types occurring on islands in Lake Kariba islands

Island	Vegetation type
110	(a) *Colophospermum mopane -Combretum apiculatum* woodland (b) *Melinis repens* wooded grassland
123	(a) *Colophospermum mopane-Combretum apiculatum* woodland (b) *Melinis repens* wooded grassland
124	(a) *Colophospermum mopane-Combretum apiculatum* woodland (b) *Melinis repens* wooded grassland
126	(a) *Colophospermum mopane-Combretum apiculatum* woodland
127	(b) *Colophospermum mopane -Combretum apiculatum* woodland
129	(a) *Diospyros quiloensis* thicket
40 mile	(a) *Colophospermum mopane -Combretum apiculatum* woodland
49	(a) *Indigofera tinctoria* shrubland (b) *Colophospermum mopane-Combretum apiculatum* woodland
Antelope	(a) *Colophospermum mopane* woodland (b) *Combretum eleagnoides* mixed woodland (c) *Melinis repens* grassland (d) *Aristida rhiniochloa* grassland
Balabi	(a) *Colophospermum mopane-Combretum apiculatum* woodland
Chasayi	(a) *Colophospermum mopane* mixed woodland (b)*Colophospermum mopane* woodland (d) Combretaceae mixed woodland (e) *Melinis repens* wooded grassland
Christmas	(a) *Combretum celastroides* woodland thicket (b) *Urochloa trichopus* wooded grassland (c) *Panicum repens* grassland
Diamond	(a) *Combretum elaeagnoides* mixed woodland (b) *Melinis repens* wooded grassland
Elephant	(a) *Karomia tettensis* thicket (b) *Pteliopsis myrtifolia* shrubland (c) *Combretum celastroides* woodland thicket (d) *Panicum repens* grassland (e) *Indigofera tinctoria* shrubland
Garden	(a) *Indigofera tinctoria* shrubland (b) *Colophospermum mopane* shrubland
Kampaka	(a) *Colophospermum mopane -Combretum apiculatum* woodland (b)*Combretum elaeagnoides* mixed woodland
Kangamani	(a) *Pteliopsis myrtifolia* shrubland (b) *Combretum celastroides* woodland thicket (c) *Melinis repens* wooded grassland
Kudu	(a) *Combretum celastroides* woodland thicket

Long	(a) *Combretum apiculatum-Colophospermum mopane* woodland (b) *Panicum repens* grassland
Lubangwa	(a) *Colophospermum mopane-Combretum apiculatum* woodland
Mambaleza	(a) *Guibortia conjugata* woodland thicket (b) *Colophospermum mopane* mixed woodland (c) *Melinis repens* wooded grassland
Marker	(a) *Colophospermum mopane* woodland (b) *Pteliopsis myrtifolia* shrubland (c) *Panicum repens* grassland
Masuko	(a) *Combretum elaeagnoides* mixed woodland (b) *Pteliopsis myrtifolia* shrubland (c) *Karomia tettensis* thicket (d) *Melinis repens* wooded grassland
Masuntu	(a) *Pteliopsis myrtifolia* shrubland (b) *Indigofera tinctoria* shrubland
Mbeta	(a) *Colophospermum mopane* woodland (b) *Karomia tettensis* thicket (c) *Melinis repens* wooded grassland
Mubenda	(a) *Pteliopsis myrtifolia* shrubland (b) *Acacia nilotica* woodland (c) *Melinis repens* wooded grassland (d) *Karomia tettensis* thicket
Namagwaba	(a) *Colophospermum mopane-Combretum apiculatum* woodland (b) *Aristida adscensionis* grassland
Namembere	(a) *Colophospermum mopane-Combretum apiculatum* woodland (b) *Karomia tettensis* thicket (c) *Diospyros quiloensis* thicket (d) *Aristida adscencionis* grassland
Nandavwi	(a) *Colophospermum mopane -Combretum apiculatum* woodland (b) *Colophospermum mopane* mixed woodland (c) *Guibortia conjugata* woodland thicket (d) *Karomia tettensis* thicket (e) *Panicum repens* grassland (f) *Melinis repens* wooded grassland
Near Masuntu	(a) *Ficus sycomorus* woodland
Patridge	(a) *Karomia tettensis* thicket (b) *Colophospermum mopane-Combretum apiculatum* woodland
Petrol	(a) *Karomia tettensis* thicket
Pimple	(a) *Colophospermum mopane* woodland
PQR	P-*Colophospermum mopane-Combretum apiculatum* woodland Q-*Colophospermum mopane-Combretum apiculatum* woodland R-*Karomia tettensis* thicket

Redcliff	(a) *Colophospermum mopane* woodland (b) *Acacia nilotica* woodland (c) *Aristida rhiniochloa* grassland (d) *Aristida adscensionis* grassland
Rhino	(a) *Mundulea sericea* shrubland (b)*Melinis repens* wooded grassland
Samunomba	(a) *Colophospermum mopane* woodland (b) *Colophospermum mopane* shrubland (c) *Melinis repens* wooded grassland
Sampakaruma	(a) *Colophospermum mopane-Combretum apiculatum* woodland (b) *Combretum apiculatum* mixed woodland (c) *Colophospermum mopane* woodland (d) *Melinis repens* wooded grassland
Seiche tower	(a) *Colophospermum mopane* woodland (b) *Panicum repens* grassland
Snake	(a) *Acacia nigrescens-Afzelia quanzensis* mixed woodland (b)*Panicum repens* grassland
Starvation	(a) *Diospyros quiloensis* thicket (b) *Panicum repens* grassland
Termite	(a)*Urochloa trichopus* wooded grassland
Tower	(a) *Colophospermum mopane* woodland (b) *Melinis repens* wooded grassland
Tsetse	(a) *Colophospermum mopane* woodland (b) *Acacia nilotica* woodland
Weather	(a) *Colophospermum mopane-Combretum apiculatum* woodland
Zebra	(a)*Colophospermum mopane* woodland (b) *Melinis repens* grassland (c) *Croton manyhartii* shrubland
Zinyama	(a)*Combretum celastroides* woodland thicket

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