Kilombero Valley Wildlife Project

An ecological and social survey in the Kilombero Valley, Tanzania

Final Report

Executive summary

- Kilombero Valley Project 97 was a multi-disciplinary collaborative study of the ecology and socio-economic context of conservation in the Kilombero Valley, Morogoro Region, Tanzania. Fieldwork was carried out within and around the Kilombero Game Controlled Area in Ulanga District between July and September 1997 by a team of British and Tanzanian scientists working in collaboration with the Ulanga District Council. We carried out the following studies:
  - A botanical inventory and community classification
  - An ornithological survey including a waterbird count and a study of the distribution of the Kilombero Weaver and two other possibly endemic species
  - A survey of the distribution and abundance of large mammals
  - A survey of the distribution and abundance of crocodiles
  - An socio-economic study in villages on the valley margins including an assessment of the potential for community-based conservation.
  - This is the final report of the project and presents the results of each individual study. The results are summarised below along with an outline of the implications of our findings for conservation and development in the valley.

Plants

- The Kilombero Valley contains a diverse and unusual flora. Around 350 species of plant were found in the valley, most of which were new records for the area. The species found included a previously unknown species of *Vigna* from the family Leguminosae that we found in the Kibasira Swamp, a composite *Grauanthus parviflorus* that has been collected only once before and is thought to be rare and possibly endangered, and the rare legume species *Crotalaria polygaloides* subsp. *orientalis.* We also found the species *Aframomum alpinum,*which is rare and possibly endangered.
- A systematic survey using a nested quadrat design was used to characterise the plant communities of the valley. Our analysis produced a classification into 8 distinct community types. We present a simple procedure for identifying each community type in the field.
- The plant communities existing in the valley represent a hydrological gradient, or a catena, from the centre to the margins of the valley. However, local variations in elevation mean that the overall pattern is a complex mosaic of communities.
- Increasing grazing by cattle, more frequent burning and cutting of timber for fuelwood will change the ecology of the woodland and wooded grassland on the margins of the floodplain considerably in at least some areas. Establishing and monitoring permanent survey plots in these areas would allow these changes to be monitored and provide an empirical basis on which to base any interventions attempting to restrict these changes.
- The existence of several species collected only rarely before and the presence of rare and possibly endangered species in the valley highlights both its botanical interest and the lack of botanical knowledge of the area as a whole. In this survey the various swamp communities in the valley were sampled less intensively and evergreen woodland (gallery forest) areas were not sampled at all. The swamp communities contain many unusual and poorly-known species and the situation is probably similar in the gallery forests. These forests also provide habitats for a considerable number of animal and bird species but are increasingly heavily exploited by people so a status survey of them should be a priority.

Birds

- The Kilombero Valley contains a diverse bird community including one and possibly three endemic species, several biome-restricted species, important numbers of waterbirds and a high density of raptors.
- Our waterbird survey largely confirmed the results of the 1995 survey. Three species in particular were found in significant numbers: African Skimmer (374), Openbilled Stork (probably over 1000) and Wattled Plover (344). Large trees in the floodplain provide roosts for many waterbird species and conservation of these should be a priority.
- The endemic Kilombero Weaver was found throughout the length of the valley wherever *Phragmites* reeds occurred. This is an expansion of the known range. The species was also observed feeding on refuse and fish out for sale in close proximity to humans, suggesting that it may be fairly adaptable. However, the species is dependent on a specific habitat that is patchily distributed within its range so it should still be regarded as Vulnerable.
- The first of the two possibly endemic *Cisticola* speces (Cisticola no 1) is readily identifiable by its distinctive song and was found throughout the valley. Its wider distribution and wider range of habitats than the Kilombero Weaver means that it should be considered Near Threatened. The second Cisticola was less conspicuous and was recorded less often but seems to have a similar range.
- The Kilombero Valley therefore meets all four criteria for being an Important Bird Area: it contains at least one and possibly three endemic species, all of which have restricted ranges, it contains 21 biome-restricted species, and it contains biogeographically significant populations of three waterbird species. An Important Bird Area description has been prepared and is presented here.
- The gallery forests in the valley may provide important cold-season habitats for montane and semi-montane species. People are exploiting them increasingly heavily so an ornithological survey and status survey should be a priority.
- Potential immediate threats to birds in the floodplain include felling of large trees that provide roosting sites for waterbirds and cutting of phragmites reeds for smoking fish which may affect the Kilombero weaver. Assuring protection and minimal disturbance of large floodplain trees should be a priority. This should preferably be achieved by negotiating local agreements. In the longer term alteration of the diverse marginal woodland and wooded grassland areas may affect many species. Continued monitoring using the same Timed Species Count method described in this report will allow any changes to be observed and provide an empirical basis for conservation action if necessary.

Mammals

- A total of 24 foot transects covering 190km were carried out to assess the distribution and densities of large mammals. However, the complex vegetation mosaic, the patchy distribution of some mammals, especially puku and very poor visibility in long grass areas meant that this method was not as successful as hoped.
- Puku occur at high densities in some short grass areas of the floodplain, but their distribution is extremely uneven. They occur at highest densities in short grass areas, but some patches are unoccupied, and they are patchily distributed even within occupied areas. They occur at much lower densities in wooded grassland areas. The sex ratio and distribution of herd composition and sizes appear to be similar to other areas where puku have been studied.
- Due to their patchy distribution neither ground transects or standard aerial reconnaissance methods are suitable for determining puku distribution or population sizes. Existing data from aerial surveys should be treated with caution.
- Puku population and density could be monitored effectively and relatively cheaply using total counts from selected points within areas of suitable habitat. An aerial survey method that explicitly takes account of the patchy distribution of puku would also be effective, but would be expensive.
- Aerial surveys remain the most effective way of monitoring elephant and buffalo populations, but emphasis needs to be put on ensuring that they take place at the same time each year.

- Ground transects could be used for monitoring zebra, eland, hartebeest and other ungulates that occur mostly in wooded grassland areas. However, due to their low density and the variable visibility in this habitat, it would require considerable time and effort to obtain meaningful data.
- Hunting is currently widespread in the Kilombero Valley, but we have no empirical evidence of its effects on animal population sizes. We suggest a potential monitoring programme that could provide information on the effects of hunting on several key species.
- Increasing numbers of cattle in the area could affect some populations of wild animals in the relatively near future. A detailed social and ecological study should be carried out to assess the potential effects of increasing numbers of cattle; this should be a priority.

Crocodiles

- A total of 247 km of river channels were surveyed at night from either a motorboat or a canoe to assess the distribution and abundance of Nile crocodiles *Crocodylus niloticus*.
- Crocodiles are abundant in the Kilombero Valley and are found in almost all river channels. Altogether 684 crocodiles were seen during this study, giving an average density of 2.77 crocodiles observed per km of channel. However, the density of crocodiles varied considerably, from almost zero on some river channels, to 7.1 per km on some parts of the Furua River.
- Crocodiles occurred even close to human habitation, albeit apparently at lower densities, for example immediately downstream of the Kivukoni ferry they were observed at a density of 2.28/km: Crocodiles do not appear to be greatly threatened in the Kilombero Valley at present. However, monitoring of crocodile numbers is advisable, especially if crocodile cropping is re-introduced.
- Monitoring of crocodile populations is most likely to be achieved effectively if carried out using a motorboat on the main river channels. Aerial surveys of crocodiles in the Kilombero Valley have proved too problematic to be useful and we suggest that using a canoe to survey crocodiles on small river channels is too dangerous for consideration as part of a monitoring programme. The cost of monitoring using a motorboat could be reduced if waterbird counts were carried out at the same time as in this survey.

Social survey

- Most villages are ethnically diverse, but the majority of people in the villages depend on crop surpluses for their income. Within each village there is a distinctly skewed distribution of well-being, with most people having very low levels of material wealth and being dependent on working in richer people's fields for subsistence. However, even most of the better off people cannot be described as materially wealthy by national or regional standards.
- The rate of immigration into the villages appears to be relatively low, and most immigrants were traders or professionals (teachers, carpenters etc). There appear to be few immigrants coming in search of land for farming.
- Pastoralists of several ethnic groups have bomas in the marginal woodland and short grass areas of the floodplain. The number of pastoralists and hence the number of cattle appears to have increased significantly over the last ten years. Most pastoralists moving to the valley came in search of grazing land due to pressures on grazing land elsewhere.
- Many villagers complained that pastoralists cattle damaged their crops without any compensation being paid and relationships between pastoralists and villagers often appeared to be poor.
- Wild animals are a significant problem for both farmers and pastoralists. Apart from external factors (this study took place in a drought year), crop damage by wild animals was regarded as by far the biggest agricultural problem. Animals impose a large direct cost on people through crop damage, and also considerable indirect costs due to the amount of time spent guarding crops from animals.

- From a development point of view, reducing the amount of crop damage by wild animals through increased numbers of game scouts, or preferably, construction of game fences around village lands, would probably be the single most effective means of increasing peoples' well-being over a relatively short time span.

Conservation

- Although the main conservation value of the Kilombero Valley has hitherto been regarded as the high densities of large mammals this study has confirmed that the valley is also significant regionally and globally for the diversity of other species, particularly birds and plants. While conservation of large mammals can indirectly result in conservation of other species, this is not necessarily always the case and conservation management in the Kilombero Valley should also take other species into account. Important examples include 1) negotiating and implementing local agreements for safeguarding key sites for waterbirds, especially large trees in the floodplain that are used for roosting and 2) assessing the conservation significance and human effects on evergreen forest areas.
- A 'community-based' conservation programme similar to that around the Selous Game Reserve aiming to conserve large mammals would probably be unlikely to achieve effective conservation if implemented by and of itself. The reasons for this include:
    - The relatively low (total and per capita) revenues available from safari hunting
    - The relatively small amount of meat available from a sustainable harvest
    - The very high costs of living with animals that villagers have to bear
    - Distributional problems arising from heterogeneity within each 'community'
    - A perceived lack of accountability and transparency of Village Councils and other governing bodies
    - The lack of targeting of benefits towards pastoralists
    - Benefits from conservation are provided as public goods.
- However, effective conservation must still include local communities. A community-based scheme could help make conservation acceptable if:
    - Conservation benefits are targeted at reducing the costs of living with wildlife, and especially the amount of crop damage
    - Emphasis is placed on creating accountable and transparent institutions for disbursement of wildlife-derived benefits
    - Pastoralists are explicitly included in the scheme.

- However, no form of community-based conservation programme is likely to be able to maintain large mammal populations at their current level on its own. To achieve this, some enforcement of hunting restrictions will continue to be necessary. However, these are most likely to be effective if they focus on increasing the probability of catching hunters, rather than imposing severe penalties. Aggressive para-military anti-poaching operations will only make it harder to get local people involved in conservation.

- If the increase in the number of cattle is found to be a conservation issue, negotiation of grazing management plans would probably be the most effective solution. It is essential that pastoralists of all ethnicities are treated as legitimate stakeholders; there are absolutely no grounds for total exclusion of pastoralists through game reserve legislation or otherwise.

Recommendations for future work

Based on our study, the following studies should be priorities for action-oriented research in the Kilombero Valley:

- Initiate a monitoring programme for key species including the following elements:

    - An aerial survey designed specifically to achieve a total count of puku numbers and distribution
    - Annual monitoring of puku numbers in selected areas of suitable habitat both near and far from villages using total counts from specific locations
    - Continued aerial monitoring of elephant and buffalo populations, but with an increased emphasis on ensuring that counts take place at the same time of year
    - Monitoring of hippo populations using total counts from specific sites, with counts carried out possibly every two or three years rather than annually
    - Continued monitoring of changes in trophy sizes for buffalo and puku.
- Carry out a detailed social and ecological study of pastoralism in the valley
- Conduct a survey assessing levels of exploitation of wild animals in Kilombero District
- Conduct a survey of consumption and supply of wild meat in Ifakara
- Conduct a botanical and zoological inventory and status survey of evergreen forest areas, including a survey of the use of forest products by people
- Repeat the waterbird counts, preferably annually, and monitor the distribution and abundance of the Kilombero Weaver

Suggested citation:

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Introduction

Background to the project

The Kilombero Valley in Morogoro Region, Tanzania, is the largest low-altitude freshwater wetland in East Africa. About 200,000 people live in the valley, for the most part highly dependent on the abundant natural resources – fish, game, crop land and grazing fodder – for their livelihoods. However, the valley also contains extremely high densities of large mammals and crocodiles that brought it to the attention of colonal and post-colonial conservationists. As a result it has been classified as a Game Controlled Area for over 40 years. Over three hundred bird species, including at least one unique to the valley, and considerable congregations of waterbirds are also found there. In addition, the plant communities of the valley were known to include some unusual species and assemblages. As a result the Kilombero Valley is a site of considerable biological interest.

However, from the late 1980's onwards concern was growing among conservationists (including the Tanzanian Wildlife Division and the World Wide Fund for Nature) that increasing human impacts on the ecosystem of the valley could lead to considerable alterations in ecosystem structure and function, including the reduction and possible local extinction of species of international conservation significance. Apart from the perceived threats to the flora and fauna of the Kilombero Valley itself, there was concern that there could be knock-on effects for the neighbouring Selous Game Reserve, a World Heritage site. The exisiting Game Controlled Area system was perceived as ineffective in achieving conservation of the area since it does not restrict land-use (agriculture, cattle-keeping, settlement) within the valley, and the level of enforcement of restrictions on hunting was thought to be very low, mostly due to a lack of man-power.

In keeping with current conservation thinking that emphasised the involvement of local communities, a proposal was made by WWF in the early 1990's for the initiation of a community-based conservation scheme with a pilot project on the northern side of the valley. However, this project fell through, officially due to a lack of funds, but also because the proposed project was felt to be too large to be workable. In the late 1990's a Irish Aid funded programme supporting the District Councils of the region was beginning to increase local-level capacity for management of natural resources and was considering initiating 'community-based' conservation using a framework pioneered by the Selous Game Reserve Buffer Zone Programme.

However, despite all this conservation interest, there was little empirical data on either the status of the flora and fauna of the Kilombero Valley, nor on the human pressures that were perceived to be threatening the ecosystem. This study was therefore conceived to investigate the biological and social factors that any conservation programme would need to take into account.

Kilombero Valley Project 97

The Kilombero Valley Project was a joint Tanzanian/British expedition carried out in 1997. It was conceived in late 1996, following discussions with the Selous Conservation Programme and the Tanzanian Wildlife Division. The core team included 7 British (all recent graduates in various disciplines) and 7 Tanzanians (with a variety of conservation/research experience). Planning and fundraising were carried out between January and June 1997 and fieldwork was carried out between July and late September, during which a total of 26 people participated in data collection. The main aims of the project were to:

- Compile a plan species inventory and characterise the plant communities of the area
- Investigate the distribution of the endemic Kilombero Weaver, compile a bird species list, and carry out a count of waterbirds
- Survey the abundance and distribution of large mammals
- Assess the distribution and abundance of crocodiles
- To obtain socio-economic information about the people living in the area and to investigate the interactions between humans and wildlife in the valley
- To synthesize this data and to draw conclusions about threats to the ecosystem and potential opportunities for conservation.

This report presents the results of the project and is divided into sections corresponding to each of the above aims.

Background: ecology and geography of the valley

Physical characteristics

The Kilombero Valley is the largest low-altitude freshwater wetland in East Africa. It is located to the west of Selous Game Reserve in south-central Tanzania (Map 1). The valley runs south-west to north-east, joining Selous Game Reserve in the east. It is about 40 km wide at an altitude of about 300 m. The valley bottom is very flat, with a difference of only about 20m in height between the sides and the centre. Longitudinally, the valley rises only about 50m in about 175km. In the North, the valley is bounded by the steep slopes of the Udzungwa Mountains while in the south, the land rises more gradually before changing to a steep escarpment that rises to the Mahenge highlands (Map 2). In the south west, the land rises into rolling hills.

In the east, the floodplain ends on a peneplain that is only about 30m above the floor of the valley (Jatzhold and Baum 1968). In the west of the valley numerous small river channels run off the surrounding highlands into the floodplain, where they join, split and re-join to form an extensive network of channels. At the eastern end, the channels have all merged into one – the Kilombero River, which is the major tributary of the Rufiji, Tanzania's largest river.

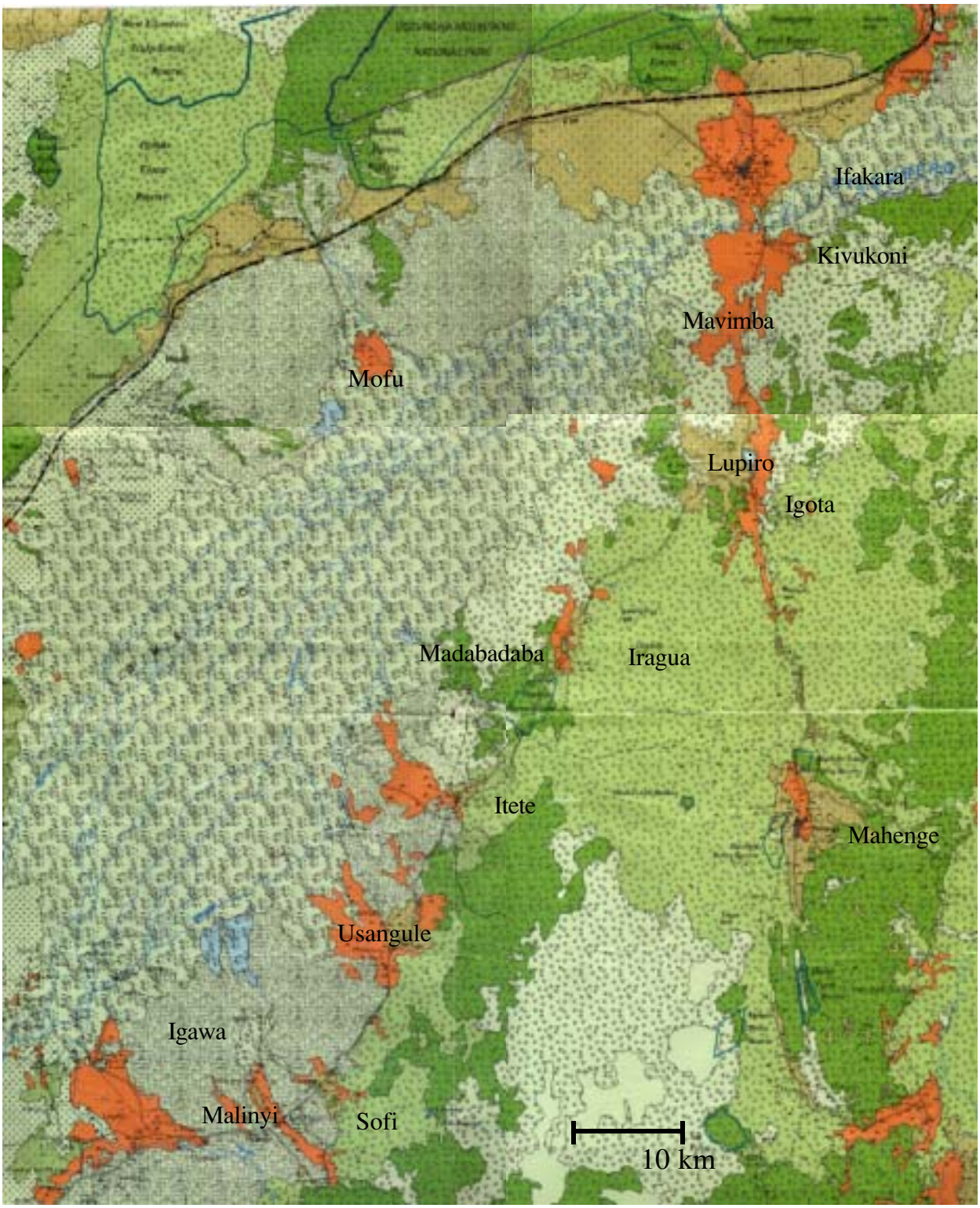
People

Approximately 200,000 people live in the Kilombero Valley (Tanzania census 1998). The majority of people are subsistence agriculturalists, who cultivate rice in the floodplain and maize on the upland and in the floodplain during the dry season. Fishing is an important livelihood occupation, and the valley is one of the largest inland fisheries in Tanzania.

Ifakara, at the eastern end of the valley is the only town in the area. The town had a population of 63,000 in 1988, but is growing rapidly, to a large extent due to improved business opportunities as a result of the improvement of the road link with Morogoro. Outside Ifakara, the population is distributed in numerous small villages, which are concentrated along the margins of the floodplain. This concentration is partly for practical reasons (near to water sources and to escape flooding), but is also a result of the villagisation campaign of 1974, when people were moved into the larger villages, and the numerous small settlements on raised ground inside the floodplain were vacated. The population density is lower on the southern side of the valley. Here, 11 villages were reported as having a total population of about 72,000 people in 1988 (Tanzania census 1988). Assuming that the population continued increasing at the long-term rate of increase for the region of 2.6% per annum (less than the Tanzanian average of 2.9%), the population at the time of the study would have been about 93,000 people.

As well as the settled population, an unknown number of pastoralists live in the valley. Their settlements ('*bomas*') tend to be well-spaced (partly for ease of access to grazing areas, and partly to avoid transmission of diseases between cattle). Some *bomas* are associated with particular villages, but some are more-or-less independent. Some of the pastoralists practice transhumanance, keeping their cattle in the area only in the dry season, whilst others remain all year round and have farms in the valley.

Map 1. The position of the Kilombero Valley in Tanzania



Map 2. Detailed map of the Kilombero Valley

Administrative structure

Administratively, the valley is divided between two Districts – Kilombero in the north and Ulanga in the south. Ifakara is the main town of Kilombero District, whilst Mahenge, in the highlands above the valley, is the main town of Ulanga District. The boundary between the two Districts is disputed; the official definition refers to the 'Kilombero River', but for much of the length of the valley, there is no distinctive 'Kilombero River' but instead a maze of channels. This was the cause of an acrimonious dispute between two safari hunting companies whilst we were in the valley.

Within the District, the area is further sub-divided into Divisions, and then Wards. Thus the settlements in Ulanga District that border the floodplain are divided into three Divisions (Lupiro, Mtimbira and Malinyi), each of which is divided into several Wards comprising 2–3 villages and smaller settlements.

Within villages, there are two main governing bodies, the Village Assembly, which comprises all members of the village over 18, and the Village Council, an elected body with 15 to 25 members (Sandi 1994). Whilst the Village Assembly technically has supreme authority, it meets rarely, and the Village Council is the body with real power as it over-sees the day-to-day business and running of the village, for example over matters such as land allocation.

Wildlife

The Kilombero Valley has long been noted for the exceptionally high density of large mammals that it contains (WWF 1992). It supports at least thirteen species of large mammal including a high density of elephant *Loxodonta africana*, buffalo *Syncerus caffer* and puku antelope *Kobus vardonii*, a species that is regarded as 'Conservation Dependent' (IUCN 1997; see Appendix 2 for the complete species list). The population of puku (known locally as *sheshe*) is one of only two in Tanzania (Rodgers 1984) and may be the largest in Africa. Although the puku remain in the valley thoughout the year, moving to slightly higher ground during the peak flooding, a large proportion of the other animals, especially elephant and buffalo, are migratory and move seasonally to and from the Selous Game Reserve that adjoins the valley at both ends (UDNRO 1997). Due to the presence of large numbers of large mammals and due to the widespread alteration of wetland habitats all over east Africa, the area has been regarded as of major conservation importance by the Tanzanian Government and international conservation NGOs (WWF 1992).

Although the populations of large mammals have been the principle focus of conservation in the Kilombero Valley, more recently the conservation significance of the Kilombero Valley for other taxa has been acknowledged. A recently identified species of weaver is endemic to the valley, and two other species of Cisitcola warblers are believed to be endemics. A waterbird count in 1995 confirmed the presence of considerable numbers of waterbirds, including regionally important populations of several species. Until this study there had been no detailed assement of the vegetation of the area, but it has been recognised that the ecosystem is unusual and that there are likely to be unusual plants in the valley.

Conservation and development

Since 1956 most of the valley has been designated a Game Controlled Area in an attempt to conserve the large populations of mammals, especially the puku. The status of Game Controlled Area, means that hunting without a permit is illegal. Hunting quotas are set each year by the Wildlife Division, the government department in charge of Game Controlled Areas and Game Reserves. The valley is divided into two hunting blocks, whose boundaries are the same as the district boundaries, and are equally disputed. A certain quota is allocated for trophy hunting, which is usually carried out by foreign residents. The fees for trophy hunting are high and charged in foreign currency (Table 1). Currently, the revenues raised from game fees go to the central treasury. A proportion (approximately 19%) is returned to the District Council. A second quota is allocated for resident hunters. Only Tanzanian nationals are allowed to hunt animals on this quota for which fees are much lower and payable in local currency (eg Tsh 6,000 or £6, per buffalo). Hunting is regulated by the District Wildlife Offices, and game scouts enforce regulations. Due to retrenchment in the civil service (in part due to World Bank/IMF structural adjustment policies), there are now far fewer game scouts than previously.

Table 1: Hunting quotas and game fees in Kilombero South hunting block in 1997

Species	Quota per season	Game fee (US$)	Total annual revenue if quota is filled (US$)
Buffalo	60	600 for the first 790 for the second 840 for the third	42,000
Lion	6	2000	12,000
Leopard	2	2000	4,000
Crocodile	8	840	6,720
Hippo	10	840	8,400
Puku	12	265	3180
All other species			14,000 (est)
Total			**90,300**

Although hunting is regulated there is no control over settlements or agriculture within the Game Controlled Area, and there are farms in many areas of the valley, including dry season farms in suitable areas of the interior of the floodplain. The amount of cultivation in the valley has been increasing, and there is therefore a perceived threat to the habitat of wild animals. Moreover, there is a perception that the level of illegal hunting in the valley is increasing. The future of the valley as a conservation area has thus been the subject of much debate within the Wildlife Division and conservation organisations operating in Tanzania.

Recent and proposed approaches to conservation

There is a widespread perception among Wildlife Division staff at both District and Central Government levels and among conservation organisations operating in Tanzania that 'if action is not taken, the conservation value of the valley will be considerably eroded over a relatively short space of time' (WWF 1992). While some people, including members of the Wildlife Division, have proposed upgrading the area to the status of Game Reserve and thus banning agriculture and settlement in the area, this is not a favoured scenario as the political fall-out would be considerable due to the large number of people dependent on the natural resources of the valley. Recent attention has therefore been focused on the potential for 'community-based' conservation. This is especially pertinet in view of the current debates over the future of Game Controlled Areas. These are perceived as being ineffective in conservation and there has recently been discussion over whether they should be upgraded to Game Reserves (which restricts settlement and entry) or be converted into community-run Wildlife Management Areas. At the time of this study, community-conservation was the favoured option.

The first proposal for a community-based conservation scheme to be implemented by the World Wide Fund for Nature was abandoned due to lack of funds (WWF 1994). Recently, however, there have been moves, supported by Irish Aid, to implement a scheme based on the Buffer Zone scheme of the Selous Game Reserve. Implementation is at an early stage, with the current focus being on awareness raising among the district and village authorities. Irish Aid has organised field trips for villagers to visit villages currently in the Selous Buffer Zone Project scheme.

The Selous Buffer Zone scheme has the following components (Ndunguru and Hahn 1998):

- Preparation of land use plans for each village, including legal demarcation and production of title deeds. Within this land use plan, Wildlife Management Areas (WMAs) are be defined, in which agriculture is prohibited by a local bye-law.
- One or more village game scouts are trained and equipped with a rifle with which to carry out hunting and problem animal control. Village scouts are normally 'young men of good standing in the village' (Ndunguru and Hahn 1998). Villages are expected to pay for the bullets to shoot animals, in order to 'impart an awareness of cost effectiveness'.
- In return for prohibiting agriculture on some areas of village land, an annual quota of animals to be hunted for meat is granted to the village by the Wildlife Division. The quota is hunted by the village

game scout and the meat sold in the villages. Money accruing from the sale of the meat should be put into a village development fund.

- A village wildlife committee will be established to manage the hunting of the quota and disbursement of the revenues. The wildlife committee will be elected by the village assembly, but will be answerable to the village council.

In addition, a proportion of the revenues from safari hunting (currently 19%) are returned to the area. This is currently paid to the District Council rather than to the villages themselves. A wildlife policy that permits all of the revenues from the game fees to be returned has been approved by the cabinet and is awaiting enabling legislation.

This study

For any conservation programme to be effective, it is necessary to have clearly-defined goals and a detailed knowledge of the existing situation. Whilst community-based conservation has recently been 'in vogue' in conservation thinking, it has tended to be easier to achieve in theory rather than in practice. Experience has shown that a detailed understanding of the social context of conservation is necessary for it to be successful. Critically, it is necessary that the 'social and ecological topography' match (Murphree 1996). In the case of the Kilombero Valley there was little indepth knowledge of either the biological or social context of conservation. This study was therefore conceived to contribute to our understanding of both the biological and social aspects of conservation in the valley.

Section 1
Botanical survey

Clockwise from top left: A hibiscus characteristic of the Long Grass plant community in the valley; Raphael Abdallah Daffa and Mr Ngalapa on a collecting trip in the Kibasira Swamp. The swamp contains many distinctive species and a new species of *Vigna* was found on this trip; A borassus palm, *Borassus aethiopum* on the edge of marginal woodland in the floodplain. These are the tallest trees in the area, and provide important roosting sites for birds. They are also tapped to make an alcoholic drink.

Section 1: Botanical survey

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Introduction

The floodplains of Africa cover an enormous area and represent vital dry season refuges for indigenous flora and fauna as well as having their own unique complement of species. The Kilombero Valley wetland has a flood area of 6,650 km^2 at high water and is one of Africa's largest wetlands (Gaudet, 1992). The floodplain is diverse in vegetative community as well as species composition and is recognised by the IUCN as being of global importance (WWF Tanzania, 1992). The flora of the Kilombero valley has to date, however, been little studied.

Descriptive accounts of broad ecological zones in the valley were made by Jätzold and Baum in 1968, and more recently the soils of the valley were classified in relation to these vegetation zones (Chase, 1994). The floodplain was described to have deep well-draining fertile clays that crack open in the dry season and are inundated in the wet season. This area supports flood grasslands and papyrus swamps. On slightly higher ground towards the edge of the plain, soil is sandier and flood savannas exist. On lower slopes deep moderately-draining red soils support miombo woodland. However, only a few species characteristic of the different zones were mentioned in these accounts. In 1996 the Ulanga District Council carried out a wet season Forest Inventory which recorded tree species present in the Ulanga forests and estimated stocking volume. Forests in the area were recognised as being species-rich and quite extensive, covering around 70% of the land area. However, only tree and shrub species were recorded and groundlayer plants remain unstudied.

These accounts of vegetation in the valley are therefore mainly descriptive and no quantitative classification of the plant communities present has ever been carried out. No species inventory exists for the valley and little plant collection has been undertaken. Only a handful of botanists (such as Cribb, Grey-Wilson, Anderson, Haerdi) have collected in the valley and their collecting localities were restricted to the close environs of certain villages, along the main river channel and near to Kivukoni Ferry (Polhill, 1988). The Kilombero Valley was highlighted as a poorly known area (i.e. the number of specimens is less than the number of species believed to grow there) according to a map produced in 1963 by the Association pour l'étude taxanomique de la flore de l'Afrique tropicale (Hedberg, 1979). This map is somewhat dated but the flora of the Kilombero Valley is still regarded as poorly known as little botanical work has been undertaken since then. Large collections from the area are therefore still necessary.

Aims

The aims of this vegetation survey were as follows:

i) To classify the different communities of plants existing in the valley and devise a scheme for identifying these communities easily for the purposes of other survey work.

ii) To compile a species inventory of all plants encountered in the valley

iii) To collect information on uses of plant species by local people

iv) To use the classification scheme for relating plant community distributions to large mammal distributions.

Methodology

Classification of plant communities

In order to classify the various plant communities present in the valley a systematic vegetation sampling method was employed. Variable length transects were orientated across vegetation gradients, normally from the centre to the margins of the valley so that each plant community was represented. Using a Garmin 12XL global positioning system unit for orientation and to measure distance walked, vegetation plots were

laid out at 200 m intervals along these transects. A nested quadrat system was used so that the size of the plot was dependent on the type of vegetation present. The abundance of grass and herb species were estimated in terms of cover using a 10-point 'Domin' scale within 2 x 2 m quadrats. Where woody elements were present in the vegetation the number of each shrub species occurring in a 10 x 20 m plot was recorded. The girth of every tree within 20 x 50 m plots was measured and the basal area of each tree species within every plot was calculated. Stems with girth at breast height (GBH) of > 10 cm were taken to be trees and any stems with a GBH of < 10 cm were counted as shrubs.

This data was analysed using Two-way indicator species analysis, or TWINSPAN (Hill, 1979, Gaugh and Whittaker, 1981). This is a widely-used classification method that divides a set of quadrats into groups on the basis of species composition. At each division of a set, similar quadrats are grouped on either side of the division and each group is defined by a certain set of species, known as indicator species. It was decided that a total of no more than 16 end groups of quadrats, and therefore plant communities, was a manageable number for the purpose of this analysis and therefore four divisions were made. The maximum number of indicators per division was set at 7. This was a compromise between a higher number that would reduce misclassification of quadrats and a lower number that would mean fewer indicator species to identify in the field. The analysis was based on presence and absence of species rather than abundance data. This was because difficulties arise when analysing plant cover data estimated on the Domin scale alongside tree basal areas, and also because the final classification is easier to use in the field if only presence/absence data is used in analysis.

Detrended correspondence analysis, or DECORANA (Hill and Gaugh, 1980) was also carried out on the data. This is a method of ordination which arranges samples in relation to each other in terms of the similarity of their species composition (Kent and Coker, 1992). Plant community data is summarised highlighting variation within the vegetation and enabling the distribution of species within different communities to be investigated. It can also be used to investigate environmental gradients correlating with vegetation composition.

The system for identifying community type using the TWINSPAN dendrogram is given in Appendix 2 of this section. This vegetation classification method provides a simple way of determining vegetation type for the purposes of other survey work.

Species inventory

Whilst carrying out the transect work every plant species encountered both inside and near to the vegetation plots was identified and included in the species inventory. In addition to this a visit was made to Kibasira swamp in Ulanga District on the North side of the valley, an area thought to contain a number of interesting species. Due to the logistical problems of carrying out transects through a swamp, no quantitative data was collected but intensive sampling was carried out in order to produce a species inventory for this area.

Species identification

Some of the more well known species encountered were identified in the field with the help of botanical keys (see reference section). In the majority of cases, however, specimens were identified or their field identifications checked at the Botany Department Herbarium, University of Dar-es-Salaam. Two botanists identified all samples taken to the herbarium separately so that all species identifications were double-checked and the chances of misidentification reduced. Duplicates of difficult specimens were brought back to the UK and identified at Royal Botanic Gardens Kew, London.

Plant uses

Any information we found on local names and uses of different plant species was recorded. This was often made available through conversations with Mr. Makoti the District Forest Officer, game guards on the team, and through encounters with people living and working around our study area. In addition to this a tree use survey was carried out in conjunction with the social survey. Ten fuelwood bundles, the size of a headload bundle, were picked at random from villagers collecting firewood and the amount of fuelwood used per household was estimated using the following formula:

$$\text{Volume} = (\pi/4) \times d^2 \times L \times Nb$$

where: d = diameter of average single firewood piece in bundle

L = length of average single firewood piece in bundle

Nb = number of individual firewood pieces in a bundle.

In addition to the data collected on fuelwood use by villagers, some qualitative information was collected on fuelwood use by pastoralists and fishermen through informal interviews. During this fuelwood study people were asked about the preferred species of trees for fuelwood, and on any other uses for tree species.

Relating mammal distribution to plant community

For this work the plant team split up and regrouped with other members of the project to form transect teams to count large mammals and assess their distribution in relation to different habitats. On each team was one member who was familiar with the indicator species that were the outcome of preliminary analyses using TWINSPAN. Foot transects were walked (26 in total) and changes in the vegetation were recorded. When a new community type was encountered the presence or absence of indicator species was noted. This transect data was then analysed using the TWINSPAN output dendrogram to determine community type from the indicator species noted. The analysis of this data is presented in the 'Mammals' section of this report.

Results

Species inventory

Around 350 species of plant were found in the valley and are listed in the annotated plant species inventory, Appendix 1 of this section. The most exciting result of the species inventory was the discovery in the Kibasira swamp of a species new to science. This is a species of *Vigna* from the family Leguminosae (Papilionoideae). We also found a composite that had only been collected once in the past named *Grauanthus parviflorus*, and which was a new addition to the herbarium at RBG Kew (the other specimen is kept in Munich). This is thought to be a rare and possibly threatened plant. In addition to this we found in miombo woodland the rare legume species *Crotalaria polygaloides* subsp. *orientalis*, and provided Kew with the best collection of this species so far.

The families that were represented by the greatest number of species were Graminae in the floodplain, and Leguminosae in wooded areas, with many of the dominant miombo trees belonging to this family. Species belonging to the family Cyperaceae were also numerous, particularly in wetter areas such as the Kibasira swamp, and species belonging to the families Convolvulaceae and Malvaceae were common in a variety of different habitats. Some of the uses of these plants are noted in the inventory and will be discussed later in this section.

Classification of plant communities

Analysis of the plant data by TWINSPAN divided the original set of 186 quadrats into thirteen smaller sets on the basis of quadrat species composition. However, some of these sets were thought to be too small to be representative of a plant community and so were amalgamated, resulting in eight different sets of quadrats. The dendrogram of the TWINSPAN output is shown in Figure 1.

The first division separated most of the wooded quadrats from the floodplain and marginal woodland quadrats. Positive indicators are mainly tree species such as *Brachystegia spiciformis*, a miombo species, and *Combretum fragans*; with one species of grass, *Hyparrhenia anamesa* being indicative of woodland plots. *Echinochloa colona* is the sole negative indicator of the other less wooded group.

In the second division the 162 samples are divided on the presence of certain species, predominantly grasses, such as *Panicum fluviicola* indicating the negative side of the division and *Sorghum verticilliflorum* on the positive side of the division. The 24 samples are divided resulting in two end sets, which represent different woodland communities.

Within division 3 the 42 samples are divided distinguishing floodplain communities on the basis of presence of wetland species such as *Phragmites mauritianus*. The group of 120 samples is divided depending on the presence of three species of grass.

The fourth and final division 4 separates the large set of 87 samples based on the presence of two tree species, the grass *Hyparrhenia colina,* and the herb *Hygrophila auriculata*. Eight different plant communities therefore emerge from the classification and are described in the text that follows. The community type in which every species encountered in the valley was found is given in the species inventory (Appendix 1).

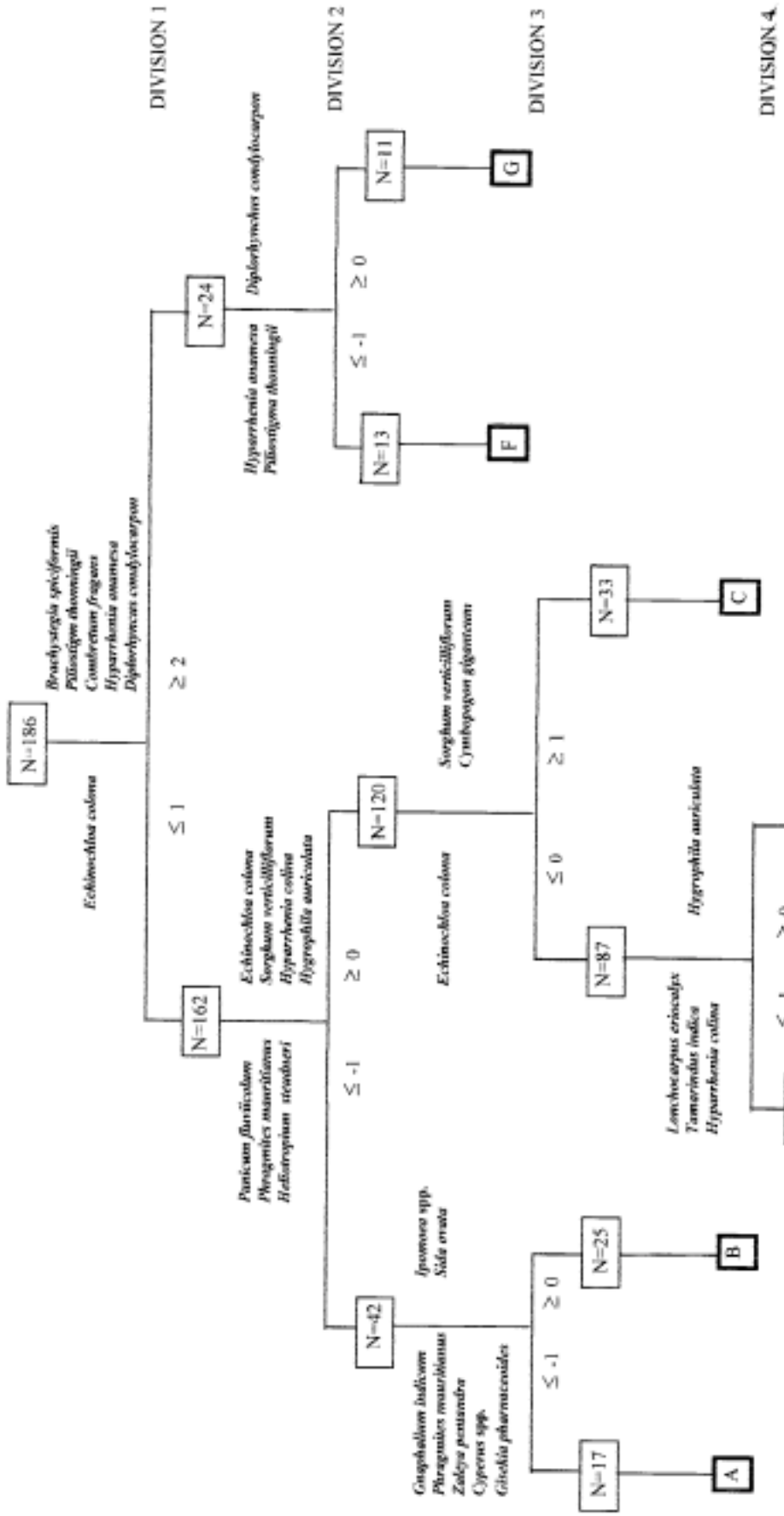

Figure 1. Dendrogram of TWINSPAN output. The letter N signifies the number of quadrats in that set, starting with a set of 186 quadrats before division at the beginning of the analysis. Indicator species are shown in italics. Those on the left of a division have a score of -1, and those on the right +1. The end set of quadrats representing a certain plant community is denoted by a letter from A-G.

A: Riverside

The perennial grass *Phragmites mauritianus* is normally dominant and can form swards over 3 m tall. Climbing plants such as *Cissampelos mucronata* and *Ipomoea plabeia* are commonly found twining up the stems of these tall riverbank reeds. On sandy banks at the edge of water or in dried up river channels young *Phragmites* may occur along with small annuals such as *Gisekia pharnaceoides*, *Zaleya pentandra* and sedges such as *Scirpus steudneri* and *Fimbristylis bisumbellata*. *Pistia stratiotes* and *Ceratophyllum demerusum* are common plants found growing in water. This community is flooded over in the wet season to the extent that no trees can survive. In the dry season areas where this community exists are often the last to dry out and consequently it is nearly always found near open water.

B: Low lying valley grassland

The perennial grass *Panicum fluviicola* is characteristic of the interior of the floodplain and often grows in dense clumps or belts over 2 m in height. However, even hardy tall grasses are drowned by flood water in some places and here shorter grasses and herbs that grow only in the dry season predominate, forming a mosaic of short and long grass areas dependent on the length of time flood water persists. In these areas of shorter sward height, herbs such as *Ludwegia abyssinica*, *Ipomoea aquatica, Heliotropium steudneri* and *Sida ovata* are common. Grasses are typically annual species such as *Ozyra longistaminata, Eragrostis aethiopica* and *Echinochloa colona*. As with the riverside community prolonged flooding means that no trees can survive in the low-lying valley grasslands.

***Echinoloa colona*, a typical species of the Low-lying Valley Grassland zone (community B)**

C: Tall grass

This community is dominated by the tall grasses *Sorghum verticilliflorum* and *Cymbopogon giganteus,* as well as *Hyparrhenia collina* in some areas. The tall grasslands are not flooded as deeply as the low-lying valley grasslands as they usually occur on slightly higher ground such as old levées. This results in the presence of occasional trees, normally *Kigelia africana*, *Acacia xanthophloea* and *Borassus aethiopum,* which are species that can withstand conditions of impeded drainage. Mean basal area in this community was, however, found to be very low at 0.17 $m^2 ha^{-1}$ as trees occur infrequently and in scattered locations. Herbs of the family Malvaceae such as *Hibiscus cannibinus* and *Urena lobata* are common, particularly around these trees, along with *Indigofera dendroides* and *Triumfetta rhomboidea*.

Leaf of *Kigelia africana* or *Mwegea*, often known as the sausage tree on account of its distinctive fruits. The trees can survive in poorly drained areas and isolated individuals are found in the Tall Grass plant community (community C)

D: Marginal grassland

Grass species such as *Echinochloa colona, Paspalum scrobiculatum* and *Panicum coloratum* are common. The most common herb is *Hygrophila auriculata,* but other species such as *Chemichrista mimosoides* may be present. This community occurs towards the margins of the flood plain and experiences shallow flooding in the wet season. Mean basal area is low at 0.13 $m^2 ha^{-1}$. It is often heavily grazed and burned in the dry season resulting in bare ground in many areas. A few shrubs such as *Grewia bicolor* and *Ziziphus mucronata* occur on termite mounds with occasional trees like *Acacia xanthophloea*.

***Ziziphus mucronata*, a shrub found on termite mounds in the Marginal Grassland community (community D)**

E: Marginal woodland

In the grass layer species such as *Hyparrhenia colina*, *Echinochloa colona* and *Digitaria ciliaris* are frequent though this area is also often heavily grazed and burned. The growth of shrubs and trees is usually concentrated on termite mounds. Tree species such as *Tamarindus indica, Lonchocarpus eriocalyx, Senna singueana* and *Dalbergia melanoxylon* are characteristic of this community, as are the shrubs *Grewia bicolor, Fleuggea virosa* and *Harrisonia abyssinica.* Mean basal area is 2.72 $m^2 ha^{-1}$, most of this wood area resulting from the presence of *T. indica* trees of large girth.

F: Combretaceous wooded grassland

The combretaceous wooded grasslands are rarely flooded. *Combretum fragans* is dominant in the tree layer and other tree species present include *Piliostigma thonningii, Terminalia sericea* and *Vitex cuneata.* Trees in this community often have small girths and are not dense resulting in a mean basal area of just 1.95 $m^2 ha^{-1}$. The grass layer is well developed and is characterised by species such as *Hyparrhenia anamesa, Sorghastrum bipennatum* and *Heteropogon melanocarpus.* Species of herb existing in this community include *Erythrocephalum minus* and *Spermacoce pusilla.*

Leaves and flowers of *Tamarindicus indica*, the tamarind tree. This tree with edible fruits is characteristic of the marginal woodland plant assemblage (community E) and individuals of this species with large girths account for the majority of the basal area in this zone.

G: Miombo woodland

Brachystegia spiciformis is the dominant tree species in the miombo woodland which exists on higher ground in the foothills of the Mahenge range. Other species such as *Diplorhyncus condylocarpon, Afzalea quanzensis, Piliostigma thonningii, Uapaca kirkiana, Pterocarpus angolensis* and *Brachystegia bussei* are also characteristic of miombo woodland in this area. and mean basal area in 7.07 $m^2 ha^{-1}$. Grass species such as *Themeda triandra*, *Eragrostis ciliaris* and *Hyparrhenia filipendula* can be found along with herbs like *Crotalaria calycina* and *Indigofera congesta*.

The result of the ordination of samples using DECORANA is shown in Figure 2. This ordination diagram illustrates the similarities and differences in species composition of the quadrats representing each community. It can be seen that the miombo woodland quadrats (group G) occupy a distinctive space on the ordination diagram showing that the miombo community is quite different from the other communities; and that most miombo quadrats have a similar species composition, as they are clustered in the lower left of the ordination. The riverside quadrats (group A) are also distinctive, but there seems to be more variation in species composition between the riverside quadrats as they are not clustered to the same extent. The Combretaceous-dominated community (group F) is distinctive, yet species composition in these quadrats seems to differ quite markedly. This seems close in species composition to the marginal woodland community (group E). Low-lying valley grassland quadrats (group B) are similar in species composition to the riverside quadrats. The marginal grassland community (group D) quadrats seem skewed toward the right of the ordination but are less distinctive. The tall grass quadrats (group C) occur around the centre of the ordination and are hard to distinguish from marginal grassland and marginal woodland. It seems that the two axes represent a moisture/elevation gradient with low elevation wetland plots occurring toward the top right of the ordination and higher elevation drier plots occurring toward the bottom left.

The ordination of species is illustrated in Figure 3. The distance between species on the plot is an approximation of their degree of similarity in terms of distribution within the quadrats, so that two species occurring in exactly the same quadrats would occupy the same points. Figure 3 therefore reflects the types of species one may expect to find in each of the communities. For example *Phragmites mauritianus* (PHRAGM) is positioned near the top of the ordination and is characteristic of the riverside community that occupies a similar space on the ordination of quadrats.

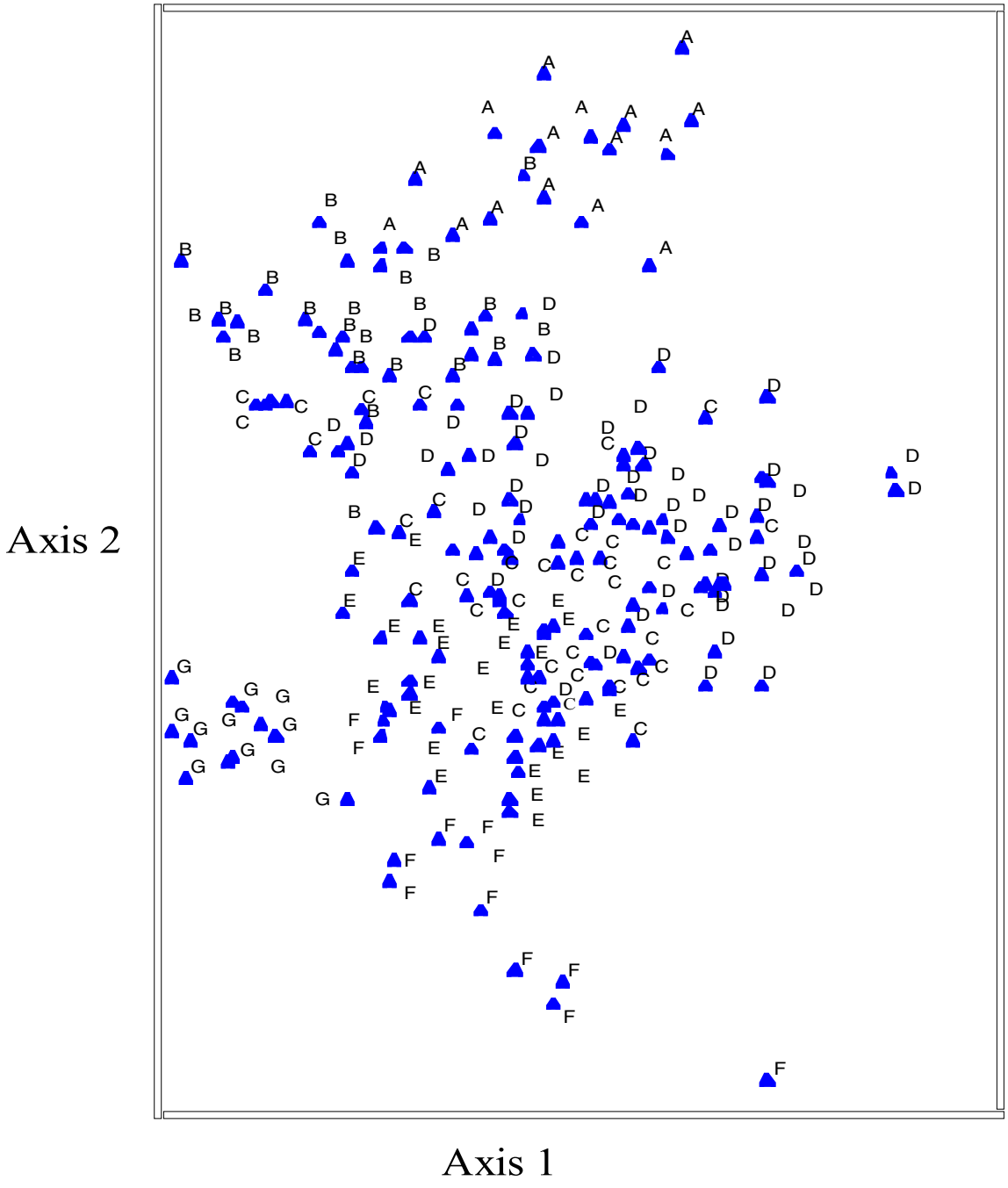

Figure 2: Two-axis quadrat ordination plot produced by DECORANA. Groupings of quadrats defined by TWINSPAN are superimposed on the ordination diagram. A= Riverside; B= Low lying valley grassland; C= Tall grassland; D= Marginal grassland; E= Marginal wooded grassland; F= Combretaceous wooded grassland; G= Miombo woodland.

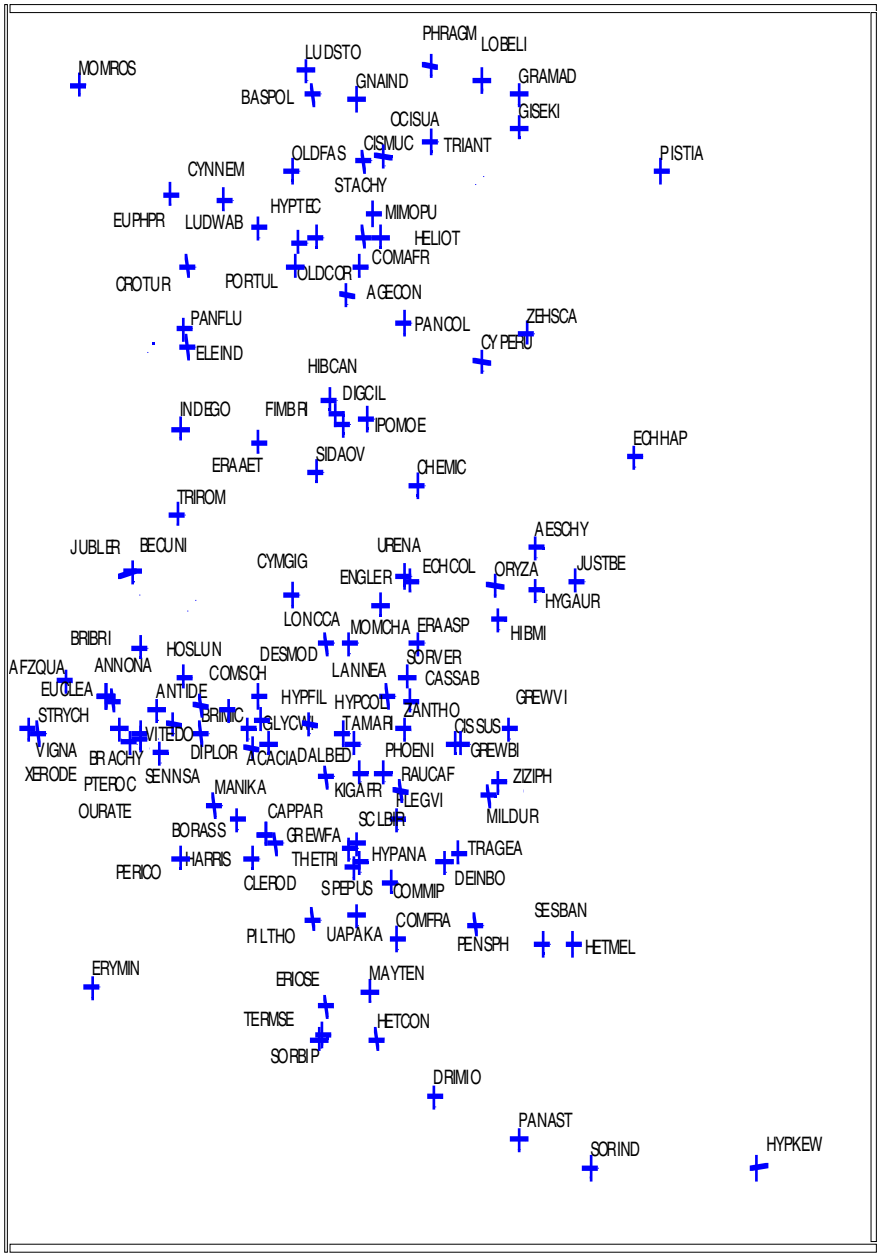

Figure 3. Two-axis species ordination plot produced by DECORANA. See following page for explanations of the abbreviations of plant names.

Figure 3 continued

ACACIA= Acacia spp., AESCHY=Aeschynomene cristata, AFZQUA= Afzelia quanzensis, AGECON= Ageratum conyzoides, ALBIZI=Albizia amara, ANNONA= Annona senegalensis, ANTIDE= Antidesma venosum, BAREGR=Bare ground, BASPOL= Basilicum polystachyon, BECUNI= Beckeropsis uniseta, BORASS= Borassus aethiopum, BRACHY= Brachystegia spiciformis, BRIBRI= Bridelia bridelifolia, BRIMIC=Bridelia micrantha, CAPPAR= Capparis tomentosa, CASSAB= Cassia abbreviata, CHEMIC=Chemichrista mimosoides, CISMUC= Cissampelos mucronata, CISSUS= Cissus sp., CLEROD= Clerodendron hildebrandtii, COMFRA= Combretum fragans, COMSCH= Combretum schumannii, COMAFR= Commelina africana, CROTUR= Croturis sp., CYMGIG= Cymbopogon giganteus, CYNNEM= Cynodon nlemfuensis, CYPERU= Cyperus spp., DALBED= Dalbergia melanoxylon, DEINBO=Deinbollia kilimandscharica, DESMOD= Desmodium salcifolium, DIGCIL= Digitaria ciliaris, DIPLOR= Diplorhyncus condylocarpon, DRIMIO= Drimiopsis sp., ECHCOL= Echinochloa colona, ELEIND= Eleusine indica, ENGLER= Englerastrum scandens, ERAAET= Eragrostis aspera, ERIOSE= Eriosema sp. ERYMIN= Erythrocephalum minus, EUCLEA= Euclea natalensis, EUPHPR= Euphorbia prostata, FICUS= Ficus sp., FIMBRI= Fimbristylis spp., FLEGVI= Fleuggea virosa, GISEK= Gisekia pharnaceoides, GLYCWI= Glycine wightii, GRAMAD= Grangea maderaspatana, GREWBI= Grewia bicolor, GREWFA= Grewia fallax, GREWVI= Grewia villosa, GNAIND= Gnaphalium indicum, HARRIS= Harrisonia abyssinica, HELIOT= Heliotropium ovalifolium, HETCON= Heteropogon contortus, HETMEL= Heteropogon melanocarpus, HOSLUN= Hoslundi oppositi, HIBCAN= Hibiscus cannibinus, HIBMI= Hibiscus migeodii, HYGAUR= Hygrophila auriculata, HYPANA= Hyparrhenia anamesa, HYPCOL= Hyparrhenia colina, HYPFIL= Hyparrhenia filipendula, HYPKEW= Hyparrhenia sp. (at Kew), HYPTEC= Hyptecia lanceolata, INDEGO= Indegofera spp., IPOMOE= Ipomoea spp., JULBER= Julbernardia globiflora, JUSTBE= Justicia betonica, KIGAFR= Kigelia africana, LANNEA= Lannea schimperi, LOBELI= Lobelia neumannii, LONCCA= Lonchocarpus capassa, LONERI= Lonchocarpus eriocalyx, LUDAB= Ludwegia abssynica, LUDSTO= Ludwegia stolonifera, MANIKA= Manilkara sansibarensis, MAYTEN= Maytenus undata, MILDUR= Milletia dura, MIMOPU= Mimosa pudica, MOMROS= Momordica rostrata, MOMCHA= Momordica charantia, OCISUA= Ocimum suave, OLDCOR= Oldenlandia corymbosa, OLDFAS= Oldenlandia fastigata, OURATE= Ouratea schusteri, PANAST= Panicum astrosanguineum, PANCOL= Panicum coloratum, PANFLU= Panicum fluviicola, PERICO= Pericopsis angolensis, PENSPH= Pennisetum sphacelatum, PHOENI= Phoenix reclinata, PHRAGM= Phragmites mauritianus, PILTHO= Piliostigma thonningii, PISTIA= Pistia stratiotes, PTEROC= Pterocarpus angolensis, RAUCAF= Rauvolfia caffra, SCLBIR= Sclerocarrya birrea subsp. caffra, SENNSA= Senna singuieana, SESBAN= Sesbania sesban, SIDAOV= Sida ovata, SORIND= Sorindaeia madagascariensis, SORCIP= Sorghastrum bipennatum, SORVER= Sorghum verticilliflorum, SPEPUS= Spermacoce pusilla, STRYCH= Strychnos spinosa, STACHY= Stachytarpheta jamaicensis, TAMARI= Tamarindus indica, TERMSE= Terminalia sericea, TRIROM= Triumfetta rhomboidea, THETRI= Themeda triandra, UAPAKA= Uapaka kirkiana, URENA= Urena lobata, VIGNA= Vigna kirkii, VITDON= Vitex doniana, XERODE= Xeroderris stulmanni, ZANTHO= Zanthoxylum chalybeum, ZEHSCA= Zehneria scabra, ZIZIPH= Ziziphus mucronata.

Plant uses

People use many plants found in the valley. The palm *Phoenix reclinata* is woven to make mats and brings an important source of income into the valley. *Tamarindus indica* is an important species of tree due to the value of its edible fruits, as is *Sclerocarya birrea*. Trees useful for building poles include *Pericopsis angolensis, Bridelia micrantha*, species of *Combretum* and *Dalbergia melanoxylon*. Species of grass such as *Panicum fluviicola*, *Hyparrhenia collina* and the *Arundinaria alpina* are useful for building, lining and thatching houses. Good timber trees include *Pterocarpus angolensis, Afzelia quanzensis* and *Milicia excelsa.* Many plants in the valley are also used medicinally such as *Syzigium guineense, Launaea carnuta* and *Cissampelos macronata*. Species such as *Albizia versicolor* are used for making handles and implements for grinding maize and rice. Many more plant uses are listed in the species inventory.

In terms of fuelwood, the survey indicated that an average of 0.88 m^3 of dry wood is removed from miombo woodland for fuelwood per household per week. However, this brief survey estimated only domestic fuelwood use and excluded the amount of fuel taken for commercial purposes like local brewing and the sale of firewood and charcoal. Also, it did not take into account the extra fuelwood consumed on special occasions for example traditional ceremonies like weddings, funerals and religious and government ceremonies. The preferred species of trees for fuelwood use in the valley are *Brachystegia spiciformis, Pericopsis angolensis, Piliostigma thonnigii* and *Annona senegalensis*. Fishermen living in temporary settlements in the floodplain, as fuel for smoking fish as well as cooking.

Discussion

Determinants of plant community types in the Kilombero valley

It is clear from these results that the plant communities existing in the valley represent a hydrological gradient, or a catena, from the centre to the margins of the valley. This is illustrated in Figure 5 that relates vegetation to elevation and soil type. Although moisture conditions are a major factor influencing the type of vegetation present in any area, other factors such as grazing, burning and local soil conditions may also be important.

At the wetter end of the catena (to the top right of the DECORANA ordination) is the riverside community (A). The type found in the Kilombero valley is similar in species composition to that of the Selous as described by Vollesen (1980). This is a special community of annual herbs and tall perennial grasses that develops on dried out sandy banks and river beds. The low relief and impeded drainage that occur in the deep floodplain are the main factors that control the vegetation and halt any further succession such as the growth of woody species (Tainton and Walker, 1993). The valley grasslands of the Kilombero valley are therefore an edaphic climax community, owing their composition to soil conditions. Communities such as this are usually of long standing and are a relatively stable formation (Vesey-Fitzgerald, 1970). They do not depend on fire for maintenance and are usually self cleaning as dead matter rots in the water during annual flooding. In the Kilombero valley fire sweeps through these areas in the dry season but can be regarded as a modifying factor with drainage being the main controlling agent. Relatively few genera and species were found to occur in this type of grassland and this is consistent with other surveys in this type of community (Lind and Morrison, 1974; Gaudet, 1992). In the lower floodplain these two types of community (riverside and low lying valley grassland) form a mosaic. This is often the case in floodplains where the complexity of vegetation is often a result of features relating to the local substratum or small differences in elevation (Gaudet, 1992).

The tall grass community was found on slightly higher ground and consisted of a greater number of species, with occasional woody species. Vegetation similar to this is found in other floodplains in Africa for example in the Kafue Flats, Zambia (Ellenbroek, 1987). The tall grass community was found mainly on old levées where small differences in elevation and soil type result in the existence of a different set of plant species and therefore add to the complexity of the floodplain vegetation. Due to a depression in the floodplain topography the Kibasira swamp does not dry out even during the dry season and vegetation in this area therefore presents another community in this floodplain mosaic. The Kibasira swamp area seems similar in species composition to the papyrus swamps described by White (1983). Conditions favourable for the development of papyrus swamp areas such as this are widespread in East Africa (Greenway, 1973).

The marginal grassland community occurring near the edge of the floodplain in the mid-catena zone was often found to be very heavily grazed and burned. This is a derived or secondary grassland and is maintained by this burning and grazing. Without these factors the composition of grassland such as this would change to include more woody components (Lind and Morrison, 1974), though edaphic factors still have an influence on the species present. Occasional termite mounds were present in this zone and supported a wider variety of herbs, a few shrubs and trees. The difference between vegetation growing on termite mounds and that of the surrounding area was, however, even more apparent in the marginal woodland community. Different and often much richer vegetation is a characteristic feature of termite mounds and a number of explanations have been proposed for why this occurs. For example, the accumulation of organic matter by termites makes soil on the mound richer in nutrients. It has been suggested that mounds are not subject to annual burning and therefore become refuges for fire tender species. Also, termites mix soil and bring soil from lower horizons to the surface resulting in deep fine grained and well-drained soil (Archibold, 1995).

On slightly higher ground marginal woodland grades into combretaceous wooded grassland. This is a common feature in Uganda and Western Kenya but is not as widespread in Tanzania where it is found mainly as a zone in the catena of miombo woodland (Lind and Morrison, 1974). This type of wooded grassland may be locally common but it is not extensive in any part of East Africa. At the driest end of the catena is miombo woodland and like the combretaceous wooded grassland this is a fire maintained type of vegetation (Tainton and Walker, 1993). The grass layer is not as prominent in miombo woodland and a tree layer that is

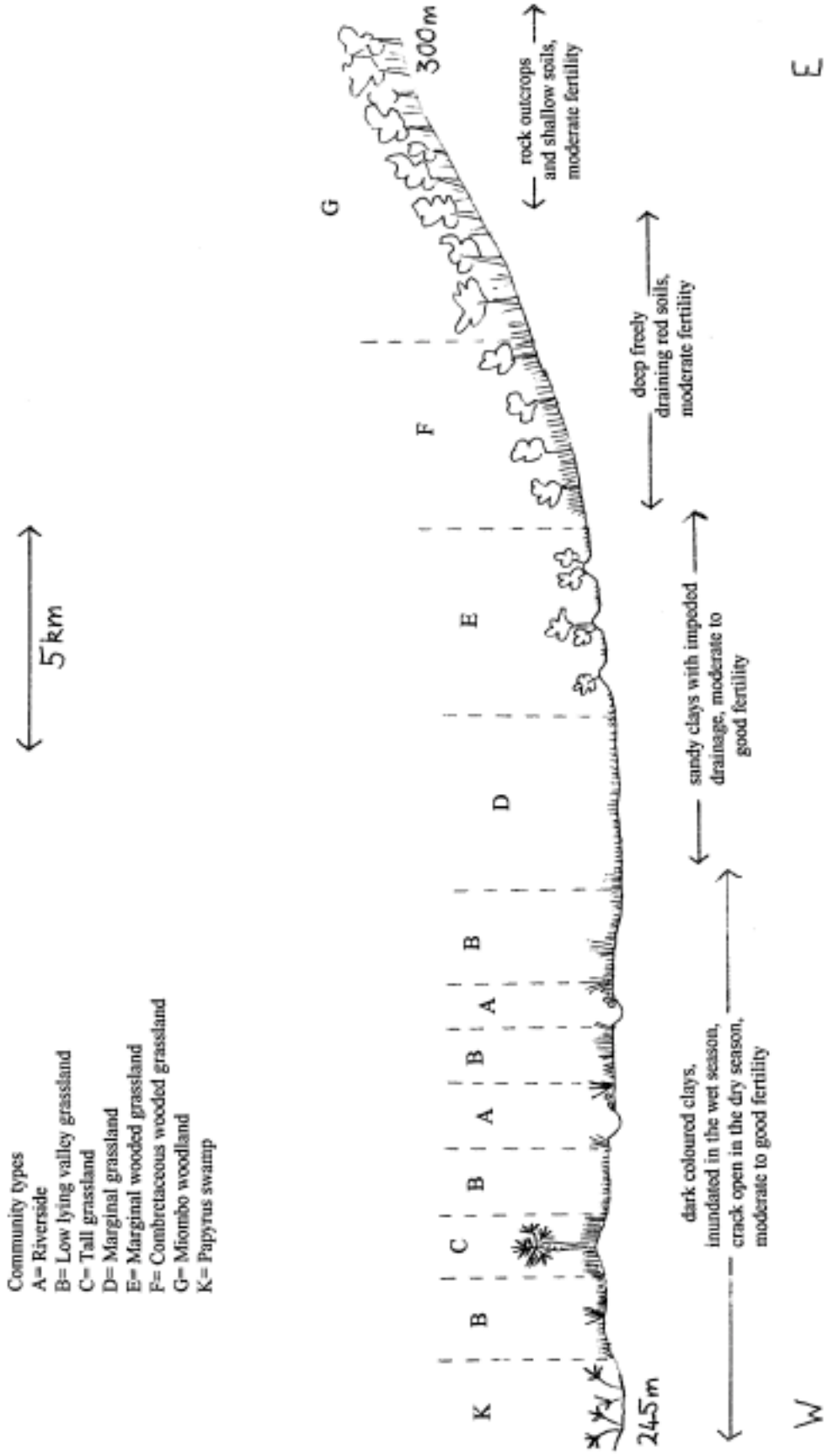

Figure 5. A diagrammatic profile of vegetation and soils in the Kilombero valley

resistant to fire predominates. Grasses that do exist here (for example *Themeda triandra*) are characteristic of drier areas (Rattray, 1968) and are quite different to those found in the floodplain. For the purpose of this survey all miombo areas are grouped together as one community but in the valley there is miombo in various stages of succession and different types of miombo occur on hilltops, hill slopes and lower areas closer to streams.

Importance of and conservation of the Kilombero valley flora

Although considerable information is available on the conservation of plant species in Europe our knowledge of the African flora is still incomplete. Due to the fact that species and their distribution are insufficiently known it is very difficult to assess the degree of threat to various species (Hedberg, 1979). From a list of seemingly rare Tanzanian vascular plants based on work by Polhill (1968) and updated by Wingfield (1979) one of the species we found in the valley (*Aframomum alpinum*) is thought to be rare and there is a chance it may be in danger of extinction. In addition to this we found a composite species that had only ever been collected once in the past and was a new aquisition for the herbarium at Kew, and we found the rare species of *Crotalaria* in miombo woodland. In addition to this and most significantly, was our discovery of a new species of *Vigna* in the Kibasira swamp. This not only confirms the importance of the Kilombero valley in terms of its plant life but also highlights the need for more plant collection in this relatively unexplored region as many species remain poorly represented or even unknown in herbaria.

As well as rare species we found a range of species significant because they are of use to people living in the valley. It has been estimated that there are over 200 marketable plant species for timber found in the various plant communities of Tanzania (Mshigeni, 1979). Though the number of species useful for timber in miombo woodland is limited, there are a few such as *Pterocarpus angolensis* and *Dalbergia melanoxylon* that are economically important. These two species are in fact reserved species, meaning that under the Forests Ordinance they are protected by law, even in unreserved land (Mgullu, 1993). The Forests Ordinance also regulates commercial exploitation of unreserved trees making it an offence to undertake commercial exploitation of any forest produce without a license from the Forest Division. Residents in the area do, however, have the right to use forest products for domestic use and consumption without license and there are many species that are widely used for fuelwood, charcoal making and house building. These species are vital to local people. Other useful species such as medicinal and edible plants are important to local people and may in future be found to be economically important for example for their curative properties. More research is needed on the properties of these medicinal species before their true value can be assessed.

Not only is the vegetation of the Kilombero valley worth conserving in its own right due to the rarity and value of certain species, but it should be considered that the vegetation provides a habitat for wild animals and birds, supports the fisheries industry, bee keeping, and rearing of domestic animals in the valley, and acts as a sediment trap maintaining the stability and fertility of the valley floodplains.

The implications of wetland conservation have been recognised internationally since the Ramsar Convention of 1971. It is now understood that wetland vegetation traps sediment which stabalises soils and riverbanks and adds to the fertility of floodplain soils (Howard-Williams and Thompson, 1985). In some areas, for example in South Africa, *Phragmites* grasses are planted in eroding water courses to reclaim eroded areas. The high rate of production in floodplains and its impact on the overall productivity of these areas is also now appreciated (Gaudet, 1992). This high rate of production is the reason that floodplains like the Kilombero can support large numbers of both wild and domestic animals. Another factor is that floodplain grasses offer better fodder quality containing a relatively high protein content, and also that they are more palatable than grasses in similarly productive non-flooded areas. The productivity of aquatic macrophytes is the reason that floodplains support a large number of fish (which are an important source of income through the valley's fisheries) and a wide variety of waterfowl. Papyrus swamps have particularly high productivity and this is reflected in high densities of birds (Finlayson and Pomeroy, 1991). In terms of habitats for wild animals and birds, however, it is not just the productivity of the floodplain that is important in the Kilombero valley. The variety of plant communities over the valley catena provide a diversity of habitat types and support a greater range of wild animals and birds. For example, miombo woodland areas provide habitats for a range of different species and also act as migration areas during the wet season, as will be discussed later in the report. The variety of vegetation types also facilitates a range of different land uses in the valley ranging from the rearing of domestic animals on the floodplain grasslands to bee keeping in the miombo woodlands, an activity that is being promoted in the area.

Threats to the vegetation of the Kilombero valley

Threats to vegetation communities can be separated into two main types: 1) species-level threats such as the risk of global or regional extinction or significant reduction in abundance of specific species and 2)

community-level threats such as the risk of significant alterations to either the plant species composition in a given area, or alterations to the physical structure of the plants in a given area.

Although the valley is now known to contain at least several species that are believed to be either rare or have restricted ranges, there do not appear to be any threats specific to these species. However, there are several anthropogenic factors that could well alter the structure or composition of the plant community in several areas of the valley.

During this survey the areas outside farmed land that seemed under the most anthropogenic pressure were the marginal grassland and marginal wooded grassland communities where intensive grazing and burning are practised by pastoralists and farmers have their fields. Large herds of cattle are grazed in a significant and increasing proportion of these areas and are grazing to the extent that bare ground often predominates. Villagers discussed this issue during focus groups as part of the social survey. Many of them believe that the cattle often cause hard pan of the soil, making it harder to work, and that pastoralists cut many trees and practice bush clearing for tse-tse fly control, locally reducing fuelwood availability. This was also discussed in the Ulanga District wildlife and forest inventory report (1997) which stated that some pastoralists (reportedly mostly waSukuma) engage in more burning of vegetation to stimulate the growth of palatable grasses, and also practice charcoal burning which can be a key factor in local deforestation and spread of fire.

The influence of fire on plant communities in the valley is not simple. Intentional burning has probably occured in Africa for at least 50 000 years and is used mainly to remove dead herbage and stimulate the growth of palatable young shoots for domestic and wild animals. The underground organs of perennial species are rarely damaged by fire and large root systems allow rapid coppicing after defoliation (Menaut, 1983). Seeds are often adapted to survive burning, for example the seeds of many grass species such as *Heteropogon contortus* require fire to break dormancy (Archibold, 1995). Indeed when burning takes place in the early dry season, woodland is hardly affected (Menaut *et al*, 1995) and growth of palatable species of grass is promoted. The miombo woodlands, combretaceous wooded grasslands and marginal woodlands of the valley can all be regarded as fire maintained types of vegetation. However, hotter late season fires kill most seedlings and saplings and can affect mature trees. Woody vegetation decreases and the ratio of grass to woody vegetation increases. This reduction in the growth of woody species seems to be occuring in the marginal woodland communities. Whether this is a new phenomenon or whether the frequency of burning has increased recently is debateable. However, in interviews during the social survey, villagers indicated that they believed that burning was becoming more frequent (though many were reluctant to discuss this). The increase in numbers of pastoralists in recent years (see the report of the social survey) also suggests that the frequency of burning could be increasing.

In addtion to burning, large concentrations of grazing animals can often alter plant species composition. Some grasses may be eliminated if grazed frequently or at susceptible stages in seasonal growth and if grasses are heavily defoliated they are unable to produce healthy roots and ultimately deteriorate (Edroma, 1981). In this study we found a reduction in the species richness of vegetation at the floodplain margins. This is most likely due to a combination of grazing and burning, but it would be difficult to say how recent a phenomenon this is.

The human population in villages is increasing, though at a slower rate than in many parts of Tanzania (see the social survey report). This population expansion may well result in changes to the plant species composition and community structure existing in the valley at present. In the social survey some people complained of land scarcity, though this was only due to local shortages rather than true scarcity. However, many people believed that the total area cultivated has increased recently. Although we had aerial photos dating from the 1960's and a recent map of vegetation zones, with which to compare it, this has not yet been carried out. Such an analysis would be a useful tool to assess empirically the changes in land use around the valley. The aerial photos have been returned to the Ulanga District Council and it is hoped that with the support of Irish Aid and Frontier Tanzania this analysis will eventually be carried out.

Increased use of trees for fuelwood, charcoal making and housebuilding and may mean over-utilisation of certain species, mostly, in the vicinity of villages. For example *Brachystegia spiciformis*, a tree popular for charcoal making, and *Pterocarpus angolensis,* a good timber tree may be depleted around villages. Whilst there is no shortage of fuelwood in the valley as a whole, some villagers interviewed for the social survey suggested that in some places firewood near the village was already depleted, meaning longer and potentially dangerous trips to collect firewood. The rate of use of fuelwood and its potential social and biological effects is an important study that should be undertaken in the near future.

In addition to this, larger scale developments such as the clearing of existing vegetation to make way for monoculture plantations of teak will cause loss of the existing plant communities in certain areas of the valley. Although we recognise that such plantations, such as those of the Kilombero Valley Teak Company, can bring benefits to the valley in terms of seasonal employment, and to Tanzania as a whole, more

attention should be paid to the local level effects that these plantations have on plant communities on which many people depend for their livelihoods.

Further work

Aside from the brief recommendations for further work discussed above, a priority for future study is a survey of evergreen forest in the forest reserve and riverine forest areas in the valley, as these were not covered during this work. Little is known about plant species composition or stocking volumes in these forests. The miombo woodlands in Ulanga district should be surveyed more extensively, and in particular the ground flora, which has never been surveyed except for during this project, which concentrated only in the foothills at the edge of the floodplain. It is especially important to assess the value of the miombo woodland resource in light of current and planned clearance of miombo to make way for teak and other plantations. Uses of plants by local people should be investigated more thoroughly using participatory assessments in villages. Information collected should include species, part of plant used, location collected, season collected and quantity collected. This information is an essential background for planning for sustainable use of plant resources. Since the incidence of fire may be increasing it would be valuable to establish some permanent plots in the various plant communities and monitor the occurrence of fires and related changes in species composition. An assessment of the productivity of floodplain vegetation would provide a means of estimating numbers of wild and domestic animals that this area can support without degradation of the existing vegetation.

It is clear that the people of Ulanga district are dependant on the vegetation that is present in a variety of ways, and that it provides a vital habitat for wild animals and birds. Prior to this survey very little was known of the botany of the Kilombero valley and this survey has provided a base of information on plant species composition and vegetation zones. Furthermore it has highlighted that it is vital we learn more about the vegetation of this area so that sustainable use of its plant resources can be practised in the future.

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Appendix 1: Plant species inventory

The plant community in which each species was found is denoted by a letter: **A**= Riverside, **B**= Low lying valley grassland, **C**= Tall grass, **D**= Marginal grassland, **E**= Marginal woodland, **F**= Combretaceous wooded grassland and **G**= Miombo woodland. Plants collected in the Kibasira swamp are indicated by the letter K, and cultivated plants that were found around villages by the letter V. Other names for plants, either in English, Swahili or Matengo, are given in brackets after the latin name and author. Descriptions of certain plants taken from the various keys and other literature (see references) are included**.**

ACANTHACEAE

Blepharis stuhlmannii Lindau **E, F**

Dyschoriste verticillaris (Oliv.)C.B.Cl. **G**

Hygrophila auriculata (Schum.)Heine An erect annual herb 0.6-1.2 m; wet places, **B,C, D, E**

Justicia betonica Linn. A weakly erect or trailing herb from a woody rootstock; a variable and widespread plant, **D**

Justicia calyculata Deflers. **D**

Justicia nyassana Lindau **E**

Monechma ciliatum (Jacq.) Milne-Redh. **F**

Nelsonia canescens (Lam) Spreng.

Rhinacanthus gracilis Clotzch

Thunbergia schimbensis S.Moore, Shrub, **G**

AIZOACEAE

Gisekia pharnaceoides L. A semi succulent annual herb; especially on sandy soils, **A**

Zaleya pentandra (L.) Jeffrey A spreading herb, slightly succulent, **A, K**

AMARANTHACEAE

Achyranthes aspera L. An annual or perennial herb or shrub; widespread in Tanzania in a variety of habitats; leaves edible, **A, D, F, G**

AMARYLLIDACEAE

Agave sisalana Perr. ex Engelm. (Sisal) **V**

ANACARDIACEAE

Anacardium occidentale Linn., **V**

Mangifera indica Blume. (Mango/Mwembe) Cultivated tree, **V**

Ozoroa insignis Del. (Mwalika) Shrub or tree 1.5-10 m, wooded grassland, often on rocky hillslopes; a root decontation can be employed against kidney trouble and diarrhoea, **G, F**

Rhus tenuinervis Engl. **K**

Sclerocarya birrea subsp. *caffra* (A.Rich.) Hochst. (Mbwegele,Mngongo) Tree 3.5-15 m, wooded grassland, riverine woodland, bushland on rocky hills, edible fruit, **D, E, F, K**

Sorindaeia madagascarensis DC. (Mtunguma, Mkunguma) Tree 8-25 m, evergreen, riverine forest, groundwater forest, **F**

Ozoroa insignis

ANNONACEAE

Annona cherimola Miller. (Custard apple) **V**

Annona senegalensis Pers. (Wild custard apple, Mtopetope, Mtokoma-mwitu) Shrub or small tree 1.5-10 m tall, grassland with scattered trees, *Brachystegia* woodland; useful fuelwood and medicinal plant; **F, G**

APOCYNACEAE

Carissa edulis Vahl. A scrambling bush; bushland, forest edges, often on termite mounds; **E, K**

Diplorhynchus condylocarpon (Muell.Arg.)Pichon (Mtogo) Tree, useful for poles and firewood, **F, G**

Rauvolfia caffra Sond. (Mkuti, Mwembemwitu) Shrub or tree 2-30 m, forest/ thicket nr. water, **G**

Tabernaemontana stapfiana Britten, **K**

ARACEAE

Pistia stratiotes L. (Water lettuce) A free floating plant with short depressed hairs giving a water repellant surface, **A, K**

ARISTOLOCHIACEAE

Aristolochia bracteata Retz. A perennial climbing herb 0-40 cm long, **E**

ASCLEPIADACEAE

Dragea abyssinica (Hoscht.) Schumann Herb with edible leaves, **K**

BIGNONIACEAE

Fernandoa magnifica Seem. (Mtisumu, Mbomba) Tree 5-20m, coppices well, roots used medicinally, **G**

Kigelia africana (Lam.) Benth. (Sausage tree, Mwegea) Tree 4.5-15 m, fruit sausage shaped, eaten by elephants, useful for fuelwood and medicine **B, C, D, E, F, K**

Kigelia pinnata D.C. **E**

Markhamea lutea K. Schum, **F, G**

BOMBACEAE

Ceiba pentandra Gaertn. (Kapok tree) Large tree, planted for making mattresses, **V**

BORAGINACEAE

Cordia africana Lam. (Mringaringa) Tree up to 10 (24) m in height, **G**

Cordia monoica Boj., (Mshasha) **K**

Cordia sinensis Lam., **F**

Ehretia cymosa Thonn. Small tree, **K**

Heliotropium baclei DC. & ADC. **B**

Heliotropium ovalifolium Forssk. Perennial herb -90 cm; wet places e.g dried mud around ponds in grassland, **K**

Heliotropium steudneri Vatke Perennial erect or spreading herb, **A, B, F**

Heliotropium zeylenicum (Bum.f.) Lam. Perennial herb; bushland and grassland, **A, B, K**

Trichodesma zeylanicum (Bum.f.)R.Br. (Camel bush) **K**

CAMPANULACEAE

Wahlenbergia abyssinica A.Rich. **G**

CAPPARACEAE

Capparis tomentosa Lam. (Mbada-paka) Scrambling shrub or woody climber 0.5-12 m, evergreen; riverine or bushed woodland, wooded grassland, secondary woodland, **E**

CARYOPHYLLACEAE

Drymaria cordata (Linn.)Willd. **B**

CELASTRACEAE

Reissantia indica (Willd.) N. Halle var. *orientalis* N. Halle & B. Mathew **E**

Maytenus undata (Thunb.)Blakelock. Shrub or tree to 1.5-12 m, evergreen; timber red, hard and heavy; forest and forest remnants, **E, G, F**

CERATOPHYLLACEAE

Ceratophyllum demersum L. Aquatic herb up to 2 m long; worldwide distribution, static to fast flowing shallow or deep water in lakes rivers or streams, **A**

COMBRETACEAE

Combretum fragans F. Hoffm. (Mlamati) Small tree to 10 (-12) m; deciduous woodland and wooded grassland, often associated with seasonally waterlogged clays, useful for building poles and fuelwood, **E, F, G**

Combretum molle G. Don. Generally a small tree 5-7 m tall, occassionally 17 m; widespread through wooded grassland and bushed areas of East Africa, **F, G**

Combretum mossambicense Engl. **E**

Combretum paniculatum Vent. **E, K**

Combretum schumanni Engl. Shrub or tree to 18 m; wide range of habitats, **F, G**

Terminalia kaiserana F.Hoffm. Small tree or shrub to 10 m; *Brachystegia* woodland, wooded grassland **G**

Teminalia sericea DC. (Mulamwili MAT) Small spreading tree 3-16 m; *Brachystegia* woodland, wooded grassland, **E, F, G**

COMMELINACEAE

Commelina africana Linn. (Libaghabagha) Spreading herb with yellow flowers **A, K**

Commelina latifolia Hoscht ex A. Rich **F, G**

Floscopa glomelata (J.A.&J.H.Schult) Hassk. **G**

Murdania simplex (Vahl.)Brenan A hairless herb with erect stems and bluish flowers **B**

COMPOSITAE

Ageratum conyzoides L. (Lijungu jungu) **A, B, E, F, G, K**

Aspilia kotschyi (Sch.Bip.)Oliv. **G**

Aspilia mossambicensis (Oliv.)Wild. **F**

Bidens biternata (Lour)Merr & Sherff. **E, G**

Bidens pilosa L. (Black Jack, Lilemera mbowga) An erect annual herb, **E**

Crassocephalum rubens (Jacq.) S. Moore **G**

Dichrocephala integrifolia (L.f.) O.Kuntz

Dicoma sessiflora Harv. **G**

Eclipta prostrata (L.)L. **K**

Erythrocephalum minus Oliv. A rhizomatous or tuberous rooted perennial herb, **F**

Ethulia conyzoides L. **G**

Hirpicium diffusum O.Hoffm. A spreading annual herb, **K**

Laggera pterodonta Sch. Bip. ex Oliver **F**

Launaea cornuta C. Jeffrey A rhizomatous perennial with erect stems, **D, K**

Gnaphalium indicum Linn. **A, B**

Grauanthus parviflorus Fayed **K**

Grangea maderaspatana Poir **A**

Melanthera albinervia Hoffm. **K**

Pterocaulon decurrens (L.)S.Moore **F**

Senecio syringifolius O.Hoffm A semi-succulent climber, **F**

Sphaeranthus suaveolensis (Forrsk.)DC. A hairless trailing herb, **B**

Spilanthes uliginosa Sw. b

Tridax procumbens L.

Vernonia sp. near *amblyolepsis* Baker **E**

Vernonia poskeana Vatke **B, K**

CONVOLVULACEAE

Astripomoea malvacea (Klotzsch) Meeuse var. *malvacea* Very variable shrubby perenneal; *Brachystegia* woodland, **B**

Dichondra repens J.R.& G.Forst. Herb with stems up to 0.6 m long; grassland, **K**

Dichondra repens

Hewittia sublobata (L.f.) Kuntze Perennial herb, pale yellow flowers; grassland, bushland, **D**

Ipomoea aquatica Forsk. Annual or perennial herb, swampy places, pond margins, **A, K**

Ipomoea blephanophylla Hall.f. **F**

Ipomoea eriocarpa R.Br. Annual, twining stems; grass/ cultivated land, often clay soils, **B, C**

Ipomoea plabeia R.Br. Annual, stems twining; we found climbing up *Phragmites*, **A, B**

Ipomoea rubens Choisy Perennial twiner, purple; Papyrus and *Echinochloa* swamps and rivers and on seasonally inundated clays and silts, **K**

Merremia hederacea (Klotzsch) Meeuse. var. *malvacea* **C, F**

CROPHULARIACEAE

Micrargeria filiformis (Schum.&Thonn.)Hutch.&Dalz

CUCURBITACEAE

Cucumis aculeatus (Lipwisha) **A**

Lagenaria abyssinica (Hook) Jeffrey **E**

Momordica charantia L. Annual climber or trailer to 5 m; riverine forest, grass thicket, sometimes cultivated, **A, B**

Momordica rostrata A.Zimm. Climber to 7 m with tuberous rootstock; wooded grassland, B *Zehneria scabra* (Linn.f.)Sond Perennial herb, climbing or trailing to 6 m; seasonal swamps, damp places, **B, C**

CYPERACEAE

Courtoisina assimilis (Steud.) P. Maquet **D**

Cyperus colymbetes Kotschy & Peyr. (Ngage - *Cyperus* spp. in general) **A, K**

Cyperus maranguensis K.Schum. **B, D**

Cyperus obtusiflorus Vahl. **K**

Cyperus papyrus Linn. Tallest member of the Cyperaceae, up to 5 m in height, widely distributed in tropical and S. Africa and Madagascar, **K**

Cyperus tenuispica Stendel **D, A, K**

Fimbristylis bisumbellata (Forsk.)Rub. **A, K**

Fimbristylis dichotoma (L.)Vahl. **B**

Fimbristylis hispidula (Vahl.)Kunth. (Likangagha) **A**

Fuirena claviseta A.Peter

Fuirena pubescens Kunth.

Kyllinga elata Kunth. **K**

Schoenoplectus sp. **B**

Scirpus brachyceras A.Rich. **F**

Scirpus cubensis Kunth. **K**

Scirpus steudneri Boeck. **A**

Scleria foliosa A.Rich **G**

EBENACEAE

Diospyros truncatifolia Caveney. Shrub or small tree 3-8 m tall; in rocky places or on termite mounds, **G**

Euclea divinorum Hiern (Mdaa) **G**

EUPHORBIACEAE

Antidesma venosum Tul. (Msazizi, Mziwaziwa) Shrub or tree 2-9 m; wooded grassland, secondary bushland at forest edge, riverine forest, moist forest, **E, G**

Bridelia bridelifolia (Pax) Fedde **G**

Bridelia micrantha (Hoscht.) Baill. Shrub or tree 2-18 m; usually riverine or in forest margins, bushed or wooded grassland; wood used for building poles and is termite resistant, **D, G**

Caperonia serrata Presl.

Euphorbia linaequilatera Sond.

Euphorbia prostrata Ait. **B**

Fleuggea virosa (Willd.) Voigt. (Mkwamba) Shrub (rarely tree) 1-6 m; riparian, in rocky bushland/ bushed grassland, wooded grassland, black cotton soil; pounded leaves are insect repellant, wood durable yielding food charcoal, fruit edible, **E, G, K**

Manihot glaziovii Muell. Arf.(Tree cassava) Used for making rubber, **V**

Paranecepsia alchorneifolia A.R.Sm.

Phyllanthus lenelllus Roxb. **K**

Phyllanthus maderaspatensis L. **K**

Ricinus communis Linn. (Caster oil plant, Mbarika) **V**

Uapaca kirkiana Muell. Arg. (Wild loquat) Tree; edible fruit, timber good, charcoal, **F, G**

FLACOURTIACEAE

Dovyalis caffra (Hook.f. & Harvey) Hook.f. (Kei apple) Edible fruit, **K**

Flacourtia indica Merrill. **F**

Oncoba spinosa Forrsk. Shrub or tree, 4-9 m; riverine forest or riverine bushland; fruit edible, wood used in furniture making, **G**

GENTIANACEAE

Canscora decussata Roem. Schult. **F**

Exacum quiquenervium Griseb. **G**

GRAMINEAE

Arundinaria alpina K.Schum (Bamboo) used for building, **V**

Beckeropsis uniseta (Nees) K.Schum. **G**

Bothriochloa glabra (Roxb.)A.Camus Tufted perennial, culms 50-150 cm; streamsides, swamp margins and cracking clays, **D, E**

Brachiaria dictyoneura (Fig &De Not)Stapf. Densely tufted perennial, culms 40-100 cm; wooded grassland and deciduous bushland, **G**

Brachiaria eruciformis (J.E.S.)Grisus Loosely tufted annual 10-60 cm; damp grassland *Cymbopogon giganteus* (Hochst.)Chiov. Tufted perennial, culms robust 1-3 m; bushland wooded grassland, often on wet soils; unpalatable to animals due to taste, **B, C, D, E, F** *Cynodon nlemfuensis* Vanderyst. (Mbuda) Stoloniferous perennial without rhizomes, **B**

Digitaria ciliaris (Retz.)Koel Annual, culms 20-100 cm, **A, B, E, F**

Echinochloa colona (Linn.)Link Annual, culms 10-100 cm; a weedy species of muddy or swampy places, **B, C, D, K**

Echinochloa haplocloda Stapf. (Lugomba) Rhizomatous perennial, culms 30-300 cm; stream banks, alluvial flood plains and black clays, **C, D**

Echinochloa ugandensis Snowden & Hubbard Annual, culms 25-80 cm; shallow pools, B *Eleusine indica* L. Tufted annual 15-85 cm; weed of roadsides and cultivated land, **B, C**

Eragrostis aethiopica Chiov. Loosely tufted annual 10-60 cm, **B, C**

Eragrostis aspera (Jacq.)Nees Tufted annual 20-80 cm, **B, C, D, E, F**

Eragrostis ciliaris (L.)R.Br. Tufted annual 5-60 cm; *Eragrostis* species are unpalatable due to texture, **G**

Eragrostis lappula Nees Perennial 30-120 cm; moist soils in *Brachystegia* woodland, **G**

Eragrostis perbela E. Schum Loosely tufted perennial 60 -100cm

Eragrostis pilosa (L.)Beauv. Loosely tufted annual 8-70 cm; roadsides, weedy places, **C**

Eragrostis tremula Steud. Loosely tufted annual 30-100 cm

Eriochloa meyerana (Nees) Pilger

Eriochloa procera O.E. Hubb. **K**

Eriochloa slamfiana (Nees) Pilger

Heteropogon contortus (L.) Roen & Schult. (Kichoma mguu) **F**

Heteropogon melanocarpus (Ell.)Benth. **F**

Hyparrhenia anamesa W.D.Clayton (Nyasa - *Hyparrhenia* spp. in general) **F, G**

Hyparrhenia collina (Pilg.)Stapf. **B, C, E, F, G**

Hyparrhenia filipendula (Hochst.)Stapf. **F, G**

Hyparrhenia finitima (Hochst.)Stapf. **F**

Leersia hexandra SW

Loudetia arundinacea (a.Rich.)Steud. **G**

Oxytenanthera abyssinica Muro. Type of bamboo planted for making local brew, V

Ozyra longistaminata Chev. Roehr. (Sapi) **B, C, D, E**

Panicum atrosanguineum A.Rich. (Uwandwe - *Panicum* spp. in general) **E, F**

Panicum coloratum L.

Panicum fluviicola Steud. (Swagoo) Perennial grass 60-230 cm; scattered throughout tropical Africa in seasonally wet grasslands on heavy clay soils or sandy soils of river banks, **A, B, C, D, E, K, G**

Paspalum scrobiculatum L. **A, B, D, E**

Pennisetum massaicum Stapf. **G**

Pennisetum polystachyum Schult. **C, D**

Pennisetum sphacelatum (Nees)Th.Dur.& Schinz **D, F**

Phragmites mauritianus Kunth A. (Matete) Perennial reed with long stout creeping rhizomes, culms erect 2-8 m high, up to 4 cm in diameter, often woody and bamboo like; banks of rivers, in swampy places, often covering large areas, **A, B, K**

Sacciolepis sp.

Sorghastrum bipennatum (Hack)Pilg. **F**

Sorghastrum stipoides Nash.

Sorghum verticilliflorum Stapf. **C, D, E, F, K**

Sporobolus macranthelus Chiov. **G**

Sporobolus virginicus (L.)Kunth. **B**

Themeda triandra Forssk. Characteristic sp. of fire climax grassland especially in dry areas, **G**

HYACINTHACEAE

Drimiopsis sp. **F**

LABIATAE

Basilicum polystachyon (L.)Moench. **A, B**

Englerastrum scandens (Gürke) Alston Trailing or scrambling woody herb; riverine bushland and rocky sites, **C, D**

Englerastrum scandens

Haumaniastrum villosum (Benth.)A.Paton **F**

Hoslundia opposita Vahl. Source of vanilla scented oil

Hyptis spicigera Lam. **B**

Leucas nyassae Gürke **F**

Ocimum suave Willd. **B**

Plecranthus sphaerophyllus Bak. **K**

LEGUMINOSAE

I. CAESALPINOIDEAE

Afzelia quanzensis Welw. (Mahogany Bean, Lucky Bean Tree) Tree 4-24 (35) m, wood shipworm resistant, durable in the ground and used in furniture making, **G**

Brachystegia bussei Harms Tree 6-20 m high; deciduous woodland, **G**

Brachystegia spiciformis Benth. Tree 5-25 m high; deciduous woodland, the most widespread and probably most frequent dominant of miombo, **F, G**

Cassia abbreviata Oliv. Shrub or small tree 3-10 m, sweet scented flowers; wooded grassland, **E**

Cassia kirkii Oliv. Erect annual herb 30-120 cm, **F**

Cassia mimosoides L. Prostrate to erect herb to 1.5 m tall; usually around forest margins, wooded grassland, cultivated and waste ground, sandy river beds and lake shores, **B, D, E**

Cassia obtusifolia L. Annual or perennial herb or undershrub; grassland, a weed in cultivated ground, often near water, **K**

Cassia occidentalis Hort.ex Steud Herb, around 1 m, B

Delonix regia (Hook.) Rafin.(Flamboyant) Ornamental tree, **V**

Julbernardia globiflora (Benth.) Troupin Tree 5-15 m, ecologically very important species of FTEA area ranging throughout *Brachystegia* areas forming tse-tse fly habit, **G**

Parkinsonia aculeata Linn. Ornamental tree, **V**

Piliostigma thonningii (Schumach.) Milne-Redh (Msekesi, *Bauhinia thonningii*)Shrub or tree to 7.5 m; woodland, wooded grassland, bushland; bark used for making rope, also useful for fuelwood and medicine**, E, K, G, F**

Piliostigma thoningii

Senna petersiana Bolle Shrub or tree 0.6-1.2 m; widespread species, **E**

Senna singueana Del. (Mbaraka) Shrub or small tree; woodland, wooded grassland, frequently noted on termite mounds, **D, E**

Tamarindus indica L.(Tamarind, Mkwaju) Tree 3-24 m; pulpy part of pod edible and used for preserves, sweets, yields refreshing drink, seeds also edible, has medicinal properties; woodland, wooded grassland, **D, E, K**

II. MIMOSOIDEAE

Acacia elatior Brenan. Tree 7-40 m, long white spines; along rivers and lakes, drainage lines, **E**

Acacia polyacantha Willd. (Falcon's claw Acacia, Mkengewa) Tree up to 21 m high, an indicator of fertile soil; riverine forest or woodland, wooded grassland, often in areas of impeded drainage, **E**

Acacia xanthophloea Benth. (Fever tree) Tree 4.5-21 m high with flat crown; in places with high groundwater; gum edible, bark decotation can be used against indigestion, **C, D, E, K**

Albizzia amara Boiv. **G**

Albizzia gummifera Smith **G**

Albizzia versicolor (Welw.ex) Oliv. (Mtanga) Tree 5-15 m; *Brachystegia* woodland, wooded grassland, wood useful for making handles, grinding maize and rice, **G**

Mimosa pudica L. (Sensitive plant) Annual or perennial herb, sometimes woody, **A, B, C, K**

III. PAPILIONOIDEAE

Aeschynomene cristata Vatke var. *pubescens* J.Leon Herb or shrub 0.9-3 (6) m; permenant and seasonal swamps, edges of dams, lakes and rivers, **C, D, F, K**

Aeschynomene indica L. (Lisayi) Erect subshrubby annual or perennial herb 0.3-2.5 m; mostly wet places, floodplain grasslands, **K**

Aeschynomene schimperi Hoscht. ex A. Rich (Mlenda) Herb, leaves occassionally sensitive, edible, **K**

Alysicarpus rugosus (Willd.)DC. Annual or perennial herb, somewhat suffructicose; grassland, seasonal wetland, **F**

Alysicarpus varginalis (L.)DC. Perennial herb, woody at base, **G**

Cajanus cajan Druce (Pigeon pea/ Mbaazi)V

Crotalaria brevidens Benth. (Lihimbilikiti) An annual or short lived perennial herb, **C**

Crotalaria calycina Schrank **G**

Crotalaria chrysochlora Baker ex Harms. **C**

Crotalaria microcarpa Benth. **E**

Crotalaria polygaloides Welw. ex Bak. subsp. *orientalis* Polh. Rare species, **G**

Crotalaria vallicola Bak.f. **C**

***Dalbergia melanoxylon* or Mpingo**

Dalbergia melanoxylon Guill. Perr (African blackwood, Mpingo SWA) Spiny shrub or tree 5-12 (30) m, much branched with dense irregular crown; deciduous woodland, often in valleys of impeded drainage; considerable commercial value, used for poles, fuelwood, medicine and carving **D, E, F***Dalbergia nyasae* Bak.f. Tree 4-9 m tall; deciduous woodland and bushland, **G**

Desmodium salicifolium (Poir)DC. Woody perennial herb or shrub; wet places, **D, F, K**

Eriosema nutans Schinz Perennial herb, thick rootstock; grassland, forest edges, seasonal swamps, **F, G**

Eriosema psoraleoides (Lam.)G.Don Erect branched subshrub or woody herb 0.75-2.4 m; grassland or bushland, margins of cultivation, **F, K**

Galactia tenuiflora (Willd.)Wight & Arn. Perennial climbing herb, velvety stems; grassland, grassland with svattered trees, **C**

Glycine wightii (Arn.) Verdc. Climber

Indigofera congesta Bak. Erect herb up to 1 m, **G**

Indigofera dendroides Jacq. **G**

Indigofera paniculata Pers Erect herb up to 1.4 m, **G**

Indigofera schimperi Jaub. & Spach. **D, E**

Indigofera schliebenii Harms. **F**

Indigofera simplicifolia Lam. **G**

Indigofera zenkeri Bak.f. **G**

Lonchocarpus bussei Hams (Msomari-Mwitu, Mwino SWA) Tree 3-15 m; wooded (palm) grassland, woodland, wooded bushland, **F**

Lonchocarpus capassa Rolfe (Mvale) **E, F**

Lonchocarpus eriocalyx Harms Small deciuous tree or shrub 5-12 (15) m; deciduous woodland, wooded (*Combretum*) grassland, **E, F, G**

Macrotyloma axillare (E.Mey.)Verdc. Perennial climbing/trailing herb 0.2-3.5 m long; grassland, seasonally flooded grassland and grassland with scattered trees, **K**

Milletia dura Dunn.(Muvunga) Shrub or small tree 3-9 (13) m; moist forest edges, also cultivated; wood tough, **D**

Mucuna poggei Taub Large liane, stems attaining 20 cm diameter, 12-30 m in height; bushland, riverine and swamp forest, **K**

Nesphostylis holosericea Verdc. Perennial climbing herb; disturbed ground formerly under *Brachystegia* woodland, grassland, **G**

Ormocarpum sennoides D.C. (Mkitaji) Shrub or small tree 1-2.5 m; **G**

Pericopsis angolensis (Bak.)Van Meuwen (Muwanga) Tree up to 17 m; deciduous woodland, usually *Brachystegia* or *Combretum*, *Terminalia* associations; wooded grasslands, useful for building poles, medicine, charcoal, **F, G**

Pseudarthria hookeri Wight. Arn Erect woody herb or subshrub 0.3-3 (4) m, **K**

Pterocarpus angolensis DC. (Mninga, Bleedwood tree) Deciduous tree 5-20 (30) m, open spreading crown; *Brachystegia* and other deciduous woodland, wooded grassland; timber is one of most valuable in Tanzania, also useful for fuelwood, medicine, protected species, **G**

Sesbania sesban (L.) Merril (Sesban, Lijekijeki) Small, short lived soft woody tree 1-7 m; near water, **C, K**

Sesbania sesban

Tephrosia hildebrandtii Vatke. **F, G**

Tephrosia reptans Bak. Perennial herb **G**

Teramnus uncinatum (L.)Sw. Perennial climber; grassland, grassland with scattered trees, **C**

Uraria picta (Jacq.) DC. Erect subshrub 02.-1.8 m tall

Vigna kirkii (Bak.)Gillett Perennial (rarely annual) climbing herb 1.8-4 m long, seasonally swampy grassland, grassland with scattered trees, sandy river banks, **K**

Vigna reticulata Hook.f. **F**

Vigna aff. *platyloba* Welw. ex Hiern. New species, **K**

Xeroderris stulhmanni (Taub.) Mendoça Sonsa (Mnyinga, Mondogondo) Tree 6-18 m; common and widespread in deciduous woodland and bushland, **G**

LEMNACEAE

Lemna minor L. (Duckweed) **K**

LILIACEAE

Asparagus africanus Lam. A much branched woody climber, **E**

Asparagus racemosus Willd. (Mahindi) **E**

LOBELIACEAE

Lobelia neumannii L. **A**

LOGANIACEAE

Anthocleista grandiflora Gilg. Tree, **K**

Strychnos cocculoides Baker **G**

Strychnos spinosa Lam. (Mtonga) Shrub or tree 3-6 m, branches often with straight or recurved spines; inland in wooded grassland, **G**

LYTHRACEAE

Ammannia aegyptiaca Willd. **K**

Lawsonia inermis Linn. (Henna) An erect shrub up to 3.5 m, sometimes spiny, **F**

Nesaea erecta Guill & Perr. **K**

MALVACEAE

Abutilon guineense (Schum.) Bak.f.& Exell **D**

Hibiscus aponeurus Sprague & Hutchison **F**

Hibiscus cannibinus Linn. (Indian hemp) Height to 2 m; yields a good fibre, much like jute, seeds yield oil that can be used for burning, **C, D**

Hibiscus migeodii Exell **D**

Hibiscus physaloides Guill.Perr. **K**

Hibiscus suranensis Linn. **C**

Pavonia patens (Andr.)Chiov.

Pavonia procumbens (Wight. & Arn.) Walp. **C**

Sida acuta Burm.f **C**

Sida ovata Forsk. (Lufyaiglu) Woody herb 0.6 m or more in height, **B, C, F**

Sida rhombifolia Linn. (Lufyayililu) **B, D, E**

Urena lobata Linn. (Congo jute, Lipyapga) Low woody herb or shrub; used for fibre, **B, D, K**

MELASTOMATACEAE

Dissotis senegambiensis (Guil &Perr.)Triana Woody perennial herb 0.3-2 m high; valley grasslands, especially damp places, **F**

MELIACEAE

Azadirachta indica A. Juss (Neem) Planted for shade, medicine **V**

Trichilia emetica Vahl. (Cape mahogany) Timber and seed-oil (can be used for candle and soap making), **K**

MENISPERMACEAE

Cissampelos mucronata A.Rich. (Lupig) Liane with woody rootstock, medicinal, **A, K**

Cocculus hirsutus Diels Liana reaching several metres in length, **E**

MORACEAE

Artocarpus heterophyllus Lam. (Jackfruit) **V**

Ficus bubu Warb. Tree to 20 m, often epiphytic; forest or riverine forest, **K**

Ficus natalensis Hoscht. Tree to 30 m tall or shrub; groundwater/ riverine forest, woodland, **E**

Ficus sycomorus Linn. (Mulberry fig, Mukuyu) Tree to 21 m, occassionally buttressed; riparian or in plaves with high groundwater table, **K**

Ficus thonningii Tree up to 15 (30) m high, **K**

Maclura africana (Bureau) Corner Shrub or tree 1.2-7m, spiny branches; dry forest , scrub, **E**

Milicia excelsa (Welw.) C.C. Berg. (Mvuli) Tree to 30 (50) m with straight bole; moist forest relicts and wooded grassland; excellent timber, **V**

MYRTACEAE

Eucalyptus spp. (Mkaratusi) Trees planted to lower water table, **V**

Psidium guajava Linn. (Guava, Mpera) **V**

Syzgium guineense (Willd.) D.C. (Mzuari) Tree 4-18m, evergreen, timber red, hard & strong, useful for fuelwood, medicine, **F**

NYMPHAEACEAE

Nymphaea caerulea (Savigny.) Verdc. (Waterlilly) **A,K**

Nymphaea lotus L. (Waterlilly) **A**

OCHNACEAE

Ouratea schusteri Engler. Tree 5-12 m, status vulnerable; moist forest, **G**

OLEACEAE

Jasminum abyssinicum R. Br. **E**

ONAGRACEAE

Ludwigia abyssinica A. Rich. (Lituri) Herb or weak shrub to 3 m; swampy ground, **A, B,D**

Ludwigia erecta (L.) Hara Annual herb, principle associate of papyrus; wet habitat, **A, K**

Ludwigia perennis L. A. Annual herb to 50 cm; swamps, floodplains, other wet habitats, **A, B**

Ludwigia leptocarpa (Nutt.)Hara Herb, some slightly woody to 2 m; wet places, **G**

Ludwigia stenorraphe (Brenan.) Shrubby or less often herbaceous; swamps by rivers and lakes, flooded grasslands, **A**

OPILIACEAE

Pentarhopalopilia umbellulata (Baill.) Hiepko (Mbugo-Lwala, Mgungo luhga) Liane or scandent shrub; *Brachystegia* woodland, dry evergreen forest, **G**

OXALIDACEAE

Biophytum abyssinicum Steud. ex A. Rich Herb with sensitive leaves, **F**

PALMAE

Borassus aethiopum Mart. Tree 7.5-30 m, 40-50 cm across trunk; in grassland with high water table, along watercourses; fruit edible, much liked by elephant and lion; palm wine can be tapped, wood termite resistant, **C, E, K, F**

Hyphaene compressa H. Wendl. (Doum palm) Tree palm to 20 m; along water courses, **E**

Phoenix reclinata Jacq. (Wild date palm, Mkindu) Clustering, very rarely solitary palm, trunks 2-10 m or more; tending to grow along waterourses; leaf fibre used for weaving and basketry providing important source of income to valley, occassionally house building, **K**

PASSIFLORACEAE

Carica papaya Linn. (Papaya) **V**

PEDALIACEAE

Sesamum angolense Welw. A shrubby annual, occasionally perennial herb, **E**

Sesamum angustifolium (Oliv.) Engl. An erect or spreading herb, **B**

Sesamum calycinum Welw. An erect herb, **F**

POLYGALACEAE

Polygala arenaria Willd. **F**

Polygala macrostigma Chod

POLYGONACEAE

Polygonum aviculare L. Agg. Much branched annual herb; arable and disturbed areas, **B, C**

Polygonum salicifolium Willd. An erect slender annual herb to 1 m; damp places, often growing in water, **A, K**

Polygonum senegalense Meisn An erect robust perennial to 3 m; lakes and riversides, often growing in water in dense stands on river banks, **A**

Polygonum strigosum R. Br. **K**

PORTULACACEAE

Portulaca oleracea L. Cosmopolitan weed, **B, D**

PRIMULACEAE

Asterolinon sp. **K**

Anagallis pumila Sw. **B**

RANUNCULACEAE

Clematis simensis Fresen Liane 5-20 m; forest margins, secondary bushland; Maasai use root decotation against malaria, **G**

Clematis simensis

RHAMNACEAE

Berchemia discolor Hemsl. **G**

Ziziphus mucronata Willd. (Buffalo thorn, Mkunazi) Shrub or small tree to 15 (30) m tall, armed with spines; open woodland, wooded grassland, **D, E**

RUBIACEAE

Breonadia microcephala (del.) Ridsdale Medium to large tree 3-21 m tall; often near water, **F**

Breonadia salicina Hepper & Wood **G**

Catunaregam nilotica (Stapf.) Tirvengadum Shrub or small tree, **E**

Gardenia ternifolia Schum. & Thonn. Shrub or small tree 1-6 m, **G**

Keetia purpurascens (Bullock.)Brids Small tree or scandent shrub, **E**

Oldenlandia corymbosa L. Annual herb; grassland, **B, D**

Oldenlandia fastigata Brem. Annual or perennial herb; open damp grassland, **A, B, D**

Psychotria goetzei (K.Schum.)Petit Shrub or small tree 1-7.5 m; evergreen forest, **K**

Rothmannia sp. Large tree, **G**

Spermacoce diabrachiata Oliv. **E, F**

Spermacoce filifolia (Schum.)DC. (Ndetetia) **G**

Vangueria madagascariensis **E, F, G**

RUTACEAE

Citrus aurantifolia Swingle(Lime/ Mdimu) Cultivated tree, **V**

Citrus limon Burm.f. (Lemon, Mlimao) Cultivated tree, **V**

Citrus paradisi Macfad. (Grapefruit, Mbalungi) Cultivated tree, **V**

Citrus reticulata Blanco. (Tangerine, Mchenza) Cultivated tree, **V**

Citrus sinensis Osbeck (Orange, Mchungwa) Cultivated tree, **V**

Zanthoxylum chalybeum Engl. Scented, spines on back of leaves and stems, **E**

SAPINDACEAE

Deinbollia kilimandscharica Taub. **E**

Dodonaea augustifolia L.f. (Mkaa-Pwani) Shrub of tree 1-6m, can withstand fires to an amazing degree; evergreen (secondary) bushland, **D, E**

Paullinia pinnata L. Liana, **K**

SAPOTACEAE

Manilkara mochisia Dubard. **G**

Manilkara sansibarensis (Engl.) Dubard (Mngambo) Small to medium sezed tree, evergreen; often lowland dry evergreen forest, useful medicine, edible fruit, firewood, **F, G**

SCROPHULARIACEAE

Alectra sessiflora (Vahl.)O.Kuntze An erect annual semi-parasitic herb, **G**

Buchnera speciosa Skan. **E, F**

Lindernia brevidens Skan. **F**

Lindernia parviflora (L.) Roxb. **F**

Stemodia serrata Benth. **F**

Striga asiatica Kuntze. Hemiparasitic herb, problem weed, resulting in loss of maize crop, **E**

SIMAROUBACEAE

Harrisonia abyssinica Oliv. **E**

SOLANACEAE

Solanum dasyphyllum Thonn (Linyacha) **C**

STERCULIACEAE

Hermannia uhligii Engl. (Mibhgabach) Shrub, **K**

Melochia corchorifolia Benh.

Melochia melissifolia Benth. **E**

Sterculia africana (Lour.) Fiori **C**

Waltheria indica L.

THELYPTARIDACEAE

Thelypteris bergiana (Schlechted) Ching **A, B**

Thelypteris sp. **K**

Thelypteris totta (Thunb.)Schelpe **K**

THYMELACEAE

Gnidia chrysantha (Solms)Gilg **F**

TILIACEAE

Corchorus pseudo-orilorius Islam & Zaid **D**

Corchorus aestuans L. **F**

Corchorus fascicularis Lam **G**

Grewia bicolor Juss. (Mkone, Mkukufua) Shrub or tree 1-8 m; dry *Acacia* bushland, bushed grassland or woodland; edible fruit, wood used in housebuilding, **D, E, G, K**

Grewia fallax K. Schum Shrub or tree 1.5-6 m; dry bushland, bushed grassland; fruit edible, **E**

Grewia micrantha Boj. Shrub or tree 3.5-6 m; riverine thicket or wooded grassland, **K**

Triumfetta flavescens Hoscht. ex A. Rich **B**

Triumfetta rhomboidea Jacq. (Muchokochore) Usually an annual but occassionally a semi-woody perennial to 1.5 m; weed of cultivation and of ruderal situations; bark fibre can be used in basketry and for string, **C**

ULMACEAE

Trema orientalis L.Bl. (Mlama tree, Mzunguzungu) Shrub, small or medium sized tree 1.2-12 m; forest margins, riverine bushland, woodland, wooded grassland, a pioneer where forest has been disturbed; fruit edible, wood very perishable, **D, E, F, G**

UMBELLIFERAE

Centella asiatica (L.) Urban **D**

VERBENACEAE

Clerodendrum hildebrandtii Vatke **E**

Stachytarpheta jamaicensis (Linn.) Vahl. Annual herb to 1 m, woody at base; widespread weed; medicinal, **A, B, C, D**

Tectona grandis Linn.f. (Teak) Tree planted for poles and timber, **V**

Vitex doniana Sweet. (Black plum, Mfundu SWA). Decidouous tree 3.5-15 m; wooded grassland or forest edge, **F, G, K**

Vitex keniensis Turrill (Meru oak) Tree 12-35 m with long clear bole; moist evergreen forest, excellent timber, **G, K**

Vitex mombassae Vatke (Mfundu maji SWA) Shrub or tree 1.8-6 m; wooded grassland or woodland/ bushland; fruit edible, **F**

VIOLACEAE

Viola abyssinica Oliv.(Lijumbashungia) Perennial herb, trailing or straggling, **C**

ZINGIBERACEAE

Aframomum alpinum (Gagnep.)K.Schum. Perennial herb, **F**

Appendix 2: Identification of vegetation type

Based on our analysis, 8 vegetation communities were defined. This flow chart describes how to identify these communities based on the presence or absence of particular indicator species (named and described in the body of the report) and using the dendrogram presented earlier. **Note**: This classification method only applies to the vegetation types studied in this survey and so will not be suitable for papyrus swamp, forested or cultivated areas.

Step 1. Learn to identify indicator species

It is essential to be familiar with the indicator species and be able to identify these easily in the field. There are around 20 indicator species and most of these are well known and should be easy to identify.

Step 2. Record presence or absence of indicator species in the area to be classified

To do this lay out plots of the following dimensions:

2 x 2 m for grasses and herbs

10 x 20 m for shrubs

20 x 50 m for trees

Then record the presence or absence of any indicator species found within these plots.

3. Use dendrogram to identify vegetation type

An indicator species that appears on the left of a division of the dendrogram (Figure 1, page 17) has a score of -1 and a species thast appears on the right has a score of +1. Work through the dendrogram like a flow chart scoring species as described, until an end point is reached. The resulting letter (from A to G) represents a certain vegetation type where A= Riverside, B= Low lying valley grassland, C= Tall grassland, D= Marginal grassland, E= Marginal wooded grassland, F= Combretaceous wooded grassland, and G= Miombo woodland.

A worked example:

For a plot containing the following indicator species: *Piliostigma thonningii*
Echinochloa colona
Sorghum verticilliflorum
Lonchocarpus eriocalyx

Division 1 *Echinochloa colona* -1
Piliostigma thonningii +1

Total score = 0 which is less than or equal to 1 so the plot lies to the left of the division

Division 2 *Echinochloa colona* +1
Sorghum verticilliflorum +1

Total score = 2 (greater than or equal to 0) so plot lies to right of division

Division 3 *Echinochloa colona* -1
Sorghum verticilliflorum -1

Total score = -2 (less than or equal to 0) so plot lies to left of division

Division 4 *Lonchocarpus eriocalyx* -1

Total score = -1 (less than or equal to -1) so plot lies to left of division

The plot is therefore similar in species composition to group E, and is therefore classified as a ‘marginal woodland’ area.

Section 2
Ornithological survey

Clockwise from top: 1) Pelicans roosting in a large Ficus tree in the floodplain. At dusk the 182 pelicans were joined by about 640 Open-billed storks names. Such trees are important roosting sites for many waterbirds and minimising disturbance to them should be a priority for conservation in the Kilombero Valley. 2) Crowned cranes in a short grass area near Lupemenda. This is a new record for the valley and a range extension within Tanzania. 3) One of the two *Cisticola* species that are found in the valley and which may well be another endemic species.

Section 2: Bird survey

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Introduction

History of ornithology in the Kilombero Valley

The importance of the Kilombero Valley for birds has been known for more than sixty years although some of these records were not published until the 1980s. Fuggles-Couchman (1984a) visited the valley from 1932-34, 1952-53 and in 1957. He found several flocks of 20-40 Black Heron on the Mnyera River in 1934 as well as African Skimmers well distributed along the Kilombero River (no date given). Williams (1966) visited the escarpment of Ulanga district during the 1960s although it is not clear if he studied the waterbirds. Entering the floodplain may have been difficult during the floods and that could be a possible reason why these excellent ornithologists missed the Kilombero Weaver *Ploceus burnieri* and *Cisticola* warblers when they visited the valley. However, this would have been the season when the weaver was in its breeding plumage and therefore at its most distinctive. Unfortunately these workers do not give any details of weavers or cisticolas seen in the valley at this time.

Reports of an undescribed weaver led to Neil and Liz Baker visiting the valley in 1988-89 and again in 1991 when they described the weaver and discovered the cisticolas (Baker & Baker 1990) and made the first surveys of the forests for the Tanzanian Bird Atlas Project. They also recorded such exciting species as Southern Banded Snake Eagle and Barred Long-tailed Cuckoo as well as planning the successful 1995 Tanzanian waterbird census which included the Kilombero Valley (Baker 1997). This census in January 1995 found White-crowned Plovers in important numbers and also found evidence that the Kilombero Valley could support important numbers of Black Heron, Goliath Heron, African Skimmer and Openbill Storks (see appendix 1). As soon as either of the cisticolas is described the Kilombero Valley will meet the criteria for Endemic Bird Areas (Stattersfield *et al.* 1998). Since 1995, little had been added to our knowledge of the avifauna of the valley, despite a number of ornithological tours visiting the area.

Current conservation status of the Kilombero Valley

Since 1995 the Kilombero Valley has been regarded as an important bird area as it meets all four main criteria for this designation (see Fishpool 1997 for definitions):

(i) threatened species
(ii) two or more restricted-range species (as soon as either of the cisticolas are described)
(iii) a significant component of the group of species confined to one biome
(iv) an important number of waterbirds (at least 1% of the regional population of a species).

Our knowledge of all these categories used to define the importance of the Kilombero Valley for birds was incomplete. The threatened status of the weaver was based on limited information, the extent of the range of the endemic birds was unknown, the waterbirds had not been counted regularly and the avian communities of different habitats were poorly known. Aside from the 1995 waterbird census (carried out in January when the flooding regime is different to the conditions during July and August when our survey was made) there has been little systematic work in the valley despite its known and predicted importance. The wildlife of the southern half of the valley was almost completely unknown as it had hardly been visited by biologists.

Aims

Our project had a number of different aims which were reached using a variety of survey techniques:

- to estimate the populations of waterbirds by a boat survey;
- to assess the population status and ecology of the Kilombero Weaver and the undescribed cisticolas;
- to survey bird communities in different habitats using timed species counts;
- to compare habitat quality and to observe which habitats were preferred by endemic and rare species;
- to conduct mist-netting and ringing, and to make sound recordings, in order to produce a more comprehensive species list for the Kilombero Valley.

Methods

The major drawback with most bird surveys compared to censuses of large mammals and crocodiles is that observers must be very skilled at species identification. Training was given during the project but as HJR was the only observer with much African bird identification experience it did, at least initially, limit the bird project to some extent. Training of team members from both Tanzania and the UK was an important part of this project as at present there are few local Tanzanian bird-watchers.

Scientific names of those bird species recorded during this survey, by Baker & Baker (1990), Baker (1997) or Baker & Baker (in prep.) are given in appendix 3. Other species mentioned in the text are given with their scientific name. Nomenclature follows that in Birds of Africa volumes I-VI (Brown *et al*. 1982, Urban *et al.* 1986, Fry *et al*. 1988, Keith *et al.* 1992, Urban *et al*. 1997, Fry *et al.* 2000). Names of species not yet included in this series are taken from Dowsett & Forbes-Watson (1993).

Survey dates

The bird survey took place between 11 July and 29 September 1997.

Waterbirds

Waterbirds were counted along most navigable river channels, during daylight hours, on the same trips as the crocodile counts and during mapping of the river channels. Surveys were carried out from boats in four main periods: 15-18/7, 4-9/8 (powered aluminium metal boat), 1-2/8 and 22-24/8 (fibreglass canoe). The canoe was used in the upper reaches of the Furua River where the water was too shallow for the metal boat.

Kilombero Weaver

The Kilombero weaver was noted wherever seen to produce a map of its distribution throughout the valley. This species was targeted during mist-netting close to Kivukoni ferry and in *Phragmites* reeds a few kilometres south of Ifakara. Possible competitors were also noted when they were seen. Baker & Baker (1990) had already identified the Golden Weaver *Ploceus subaureus* as a competitor. It was intended to map the distribution of old 'male' *P. burnieri* nests (breeding season is earlier in the year in the rainy season) but this proved difficult. Firstly, it was not possible to identify nests as having been made by *burnieri* whilst the observer was in a moving boat and closer observation showed that the majority could have been unfinished male nests. However, old nests were mapped downstream of Kivukoni towards Boma Ulanga in the Selous Game Reserve as close approach was possible in a slow-moving boat, this is based on the assumption that no other weaver species breed colonially in reeds in the floodplain.

Cisticolas

Cisticolas were noted whenever seen to attempt to produce a map of the distributions of both undescribed species and to distinguish them from other species. There were problems in sight identification of both species. However the call of one is very distinctive and allowed clear identification when heard.

Timed species counts

Timed species counts (TSCs) were carried out to compare bird communities in different habitats using the method described by Pomeroy & Tengecho (1986). This method is based on the assumption that common birds are on average more likely to be seen first and rarer birds may take longer to find. The majority of the timed species counts were carried out at the same time as the large mammal censuses as this provided economy of effort, especially with regard to logistics and ensured our overall project methodology was easily repeatable. Only in wooded short grass areas were TSCs found to require a slower pace than the mammal surveys, and this was not the case all of the time. In fact, with increasing observer skill at identification and familiarity with local species, this ceased to be a significant problem.

General observations were made whenever possible to produce a complete bird list for the Kilombero Valley. Bird records from Tanzania are being compiled for the Tanzanian Bird Atlas Project by Liz and Neil Baker. Observations from each month and for each of the four quarter-degree squares (the unit of analysis for the atlas project) within which the valley lies, were compiled for the atlas project.

Mist-netting

Mist-netting was carried out at any opportunity. There was insufficient time to carry out systematic mist-netting to produce estimates of capture rates as intended in the proposal. This was not a particular problem as studies have found mist-netting to be an inefficient use of time during short-term intensive surveys as a technique to estimate population sizes, species totals and relative abundance (Fjeldsa & Rabol 1995, Svendsen & Hansen 1995, Poulsen & Krabbe 1998). *Ploceus burnieri* was targeted by the river surveys, as stated above, and was caught especially close to Kivukoni. Netting also took place in gallery forest along the Ruipa River near Mofu and in Kibasira Swamp as this potentially important habitat was being cleared for crops. Kibasira, at present, is too remote to suffer from direct habitat loss as result of agriculture but there is already evidence of heavy livestock grazing nearby. Data collected whilst Kibasira is relatively unmodified should allow the severity of future changes to be gauged more accurately. Tape recordings were made of birds at night and of the undescribed cisticolas to aid identification.

Waterbird survey

Introduction

The first major co-ordinated waterfowl count in Tanzania took place in January and February 1995 (Baker 1997). This was part of the African Waterfowl Census which has been operating since 1991 in around 25 countries (Dodman & Taylor 1995). The Tanzanian census included a survey of the Kilombero Valley and made counts along 140 km of river upstream of Boma Ulanga (Selous G.R.). The 1995 survey counted an important number of White-crowned Plovers (476) and they also counted large numbers of Black Heron, Goliath Heron, African Skimmer and Openbill Stork although none of these latter species reached internationally important levels. The threshold of important numbers is defined as 1% of the biogeographic population of a congregatory waterbird. These figures are mostly taken directly or derived from Rose & Scott (1994) or Rose & Scott (1997). Further modifications have been made by Fishpool (1997).

The main goals of the African Waterfowl Census are to:

1) establish a monitoring scheme for African wetlands;
2) determine the seasonal distribution of waterbirds;
3) determine population estimates of waterbirds and monitor trends;
4) promote awareness of African wetlands through increased participation.

The National Wetlands Programme for Tanzania has put forward recommendations which we hoped to incorporate into our survey (Katondo 1997). These included determining:

1) names and locations of wetlands;
2) biological diversity;
3) ecological and socio-economic values;
4) threats to wetlands and their biodiversity;
5) conservation status.

Our survey aimed to work towards the goals of the African Waterfowl Census and Tanzania's National Wetlands Programme and also to add to the work already carried out in the Kilombero Valley. In particular we were keen to assess the waterbird population levels during the dry season when many birds would be breeding on exposed sand banks, northern migrants would be absent (allowing Afrotropical population sizes to be identified) and the near-threatened Madagascar Squacco Heron would possibly be found. We were also keen to count those species which the 1995 survey had suggested may be found in important numbers and also to count along some of the smaller channels further south. The first recommendation of the National Wetlands Programme is important as recently there has been some confusion over names within the Kilombero Valley. Kibasira swamp is an area of floating papyrus *Papyrus sp.* swamp south and west of Mofu village on the north side of the valley. This name does not apply to the Kilombero Valley floodplain as a whole nor to any other swamps within the myriad of ponds and channels. It was also of great value to our other survey groups to map the various channels within the valley as they can change dramatically between years during the floods and available, 30-year old maps we had obtained were effectively useless with regard to smaller rivers. The dynamics of the river channels are probably influenced by enlargement of channels and runs by hippopotamus.

Methods

We carried out river surveys on a number of dates:

15-18/7	Kivukoni to Mofu (including some rivers south of Mofu) to Kivukoni
1-2/8	Malinyi to Mnyera River (02045, 90385)
4-9/8	Boma Ulanga to Furua River (02579, 90037) to Kihansi River (02635, 90954) to Kivukoni
22-24/8	Furua River (01812, 90098 to 01857, 90554)

Waterbirds were counted along most navigable river channels, during daylight hours, on the same trips as the night-time crocodile counts and mapping of the channels. Some of these surveys duplicated each other but care was taken to divide the counts into separate sections so censused populations do not include duplicate counts. Four or five people took part in the surveys; each team consisting of a skilled bird observer, an armed guard, a boatman and a navigator. The survey team on 22-24/8 did not have an experienced ornithologist present. As a result some of the more difficult species such as plovers and sandpipers were missed. This will have resulted in undercounting, nevertheless it provided useful counts of distinctive species such as Skimmer and Giant Kingfisher.

All of these surveys except 1-2/8 were carried out from an aluminium motor boat with a shallow draft loaned by the Selous Game Reserve which allowed most rivers to be surveyed. The survey on 1-2/8 was made from a fibreglass canoe kindly loaned by James Maynard of Wild Footprint Safaris who participated in two parts of the survey. The canoe was used because in the dry season the upper Mnyera River is very shallow and narrow.

Results

See Appendix 1 for total counts. Three species were found in important numbers: White-crowned Plover (324 individuals), African Skimmer (376 individuals) and Openbill Stork (665 + roosts). Only 665 Openbill Storks were recorded during the waterbird survey but three roosts of 607, c.200 and c.100 were found away from the waterway survey. Although some of these will be duplicate counts, some large flocks were counted at a great distance (20 km) from the roosts and therefore these will probably be different individuals and the total will probably exceed the 1% threshold of 1,000. Other species were recorded in large numbers during the waterbird surveys; Yellow-billed Stork (198 individuals), Water Thicknee (153), Common Pratincole (814) and Wattled Plover (344). The latter two species were also found in very large numbers on grazed grassland during August and September (see Timed Species Counts scores) and they are probably found in important numbers. Tanzanian counts of the Yellow-billed Stork in 1995 indicated that the IWRB population estimate may be too low (Baker 1997).

Discussion

African Skimmer

It is possible that this may be largest count of Skimmers at a breeding site in Tanzania, given the numbers of adults found here, although only 5 nests were found. The 1995 count found 726 at Nyumba ya Mungu in northern Tanzania but they do not apparently breed at this site (Baker 1997). The African Waterfowl Census of July 1995 and January 1996 took place in 25 countries and important numbers of Skimmers were recorded only on the Victoria Nile in Uganda (Dodman & Taylor 1996). Along the entire mid and upper Zambezi, within Zambia and Zimbabwe, 1428 birds were counted during the breeding season (Coppinger *et al*. 1988). These surveys covered much greater distances along bigger rivers and give an indication of the density and importance of the Kilombero population. The Southern African Bird Atlas shows that the population has declined drastically in that region and should now be regarded as regionally threatened (Tree 1997) and globally near-threatened (Stattersfield *et al*. 2000). The world population is estimated to be less than 10,000 (del Hoyo *et al*. 1996) and therefore almost 4% of the world total, 10% of the Tanzanian total of 4000 individuals (Baker 1997), is found in the Kilombero Valley.

Openbill Stork

Our counts during the waterbird survey did not reach the biogeographic threshold level of 1000 individuals (see Appendix 2) (Fishpool 1997). However, the count of 665 in conjunction with three fortuitous observations of roosts (totals of 609, c.200 and c.100) and other anecdotal observations (e.g. a flock of 95 on 7/8 after the main survey) indicate that this valley is probably important for this species. Undoubtedly some of the birds observed during the waterbird surveys include those using these roosts and therefore the counts cannot be added

directly to the roost numbers. The birds in the valley are probably an integral part of the population in the Selous Game Reserve (Baker 1997).

White-crowned Plover

Our count of 324 during the waterbird survey confirms the area as important for this species as both this count and that in 1995 of 476 (Baker 1997) are above the 1% threshold level of 250 (Fishpool 1997) (see Appendix 2). The presence of these numbers in both dry and wet seasons indicates that this population is probably resident. Baker (1997) extrapolates the 1995 data and suggests that there may be a further 1360 White-crowned Plovers on 400 km of suitable habitat upstream from that survey. However, many of the channels upstream are narrow and very steep as a number of rivers have merged and would therefore be less suitable. A figure of half this, 680 individuals, could perhaps be more accurate. Compensating for this, however, our TSCs in long grass areas found that one of the commonest birds was the White-crowned Plover, scoring 3.3. This species preferred moister areas of short grass within the long grass habitat. As the Kilombero Valley is absolutely unique ecologically (Baker & Baker 1990, this study) it is perhaps unlikely that this species will be found in grasslands elsewhere in Tanzania, although larger river valleys in Zambia could be comparable in character.

No absolute counts during TSC surveys were made so estimation of numbers is difficult. This species could indeed be found in very large numbers, perhaps exceeding the numbers suggested by Baker (1836 individuals) but without further evidence the population cannot be estimated to be more than this.

Grassland birds

Large populations of ‘waterbirds’ were found on grassland areas. Some species were found in both waterside and grassland habitats whilst others are obligate grassland specialists. The table (2.1) below shows some of these species found during our study:

Table 2.1. Lists of waterside and grassland ‘waterbirds’.

Waterside/grassland species	Grassland specialists
Cattle Egret	Spotted Thick-knee
Marabou	Senegal Plover
Egyptian Goose	Temminck's Courser
Common Pratincole	Wattled Plover
White-crowned Plover	
Blacksmith Plover	

It is obviously not suitable to estimate the population sizes of grassland specialists from waterway surveys and the species found in both waterside and grassland habitats will almost certainly have their numbers and relative abundance underestimated by using waterway surveys alone. A suitable technique for grassland surveys of these species would be belt transects (Reed & Fuller 1983, Avery 1989, Bibby, Burgess & Hill 1992) and it could be possible to extrapolate the population estimates produced for suitable habitat throughout the valley. Quantitative grassland surveys would be very useful for the White-crowned Plover which has already been found in important numbers in the valley and the grassland in the Kilombero Valley could hold very large numbers. It was found to be one of the commonest species in long grass areas, scoring 3.3 in TSCs (see bird community survey section). This species is normally not found at any distance from water so the presence of this species in areas well away from water is interesting. Both the Common Pratincole and the Wattled Plover were found in numbers close to the 1% population threshold during the waterbird survey. These species were found to be quite common during TSCs, the Wattled Plover being the most frequently observed species on short grassland. Therefore, it is very likely that both species would be found in important numbers on grassland.

Palaearctic migrants

The 1995 survey was conducted during the northern winter but despite this only six Palaearctic migrants were recorded in 1995 which were not seen during our 1997 survey (Table 2.2):

Table 2.2. Palaearctic migrants not recorded by us.

Eurasian Marsh Harrier
Little Ringed Plover
Green Sandpiper
Wood Sandpiper
Little Stint
Temminck's Stint

None of the Palaearctic migrants were recorded in large numbers. We recorded Wood Sandpiper, Spotted Redshank and Marsh Sandpiper after the main survey, the latter two had not been recorded previously. Palaearctic migrant waterbirds have not been recorded in large numbers at anytime in the Kilombero Valley and therefore it is safe to assume that it is of little importance for these birds.

Other species

Two species, African Fish Eagle and Water Thick-knee have similar counts for both 1995 and this study (Appendix 1), despite the fact that the same rivers were probably not surveyed because of the numerous different channels. This is probably an artefact of the counting. Although the 1995 count was after the small rains and therefore much of the riverbank was flooded and the surrounding habitat was mostly inundated, it is possible that these two species may hold feeding or breeding territories in both seasons, indicating that the population may be resident throughout the year. Previous studies have shown that population densities of the Fish Eagle remain relatively constant over many years (Eltringham 1975, Krueger 1997) and so counts from waterways may be an effective method of population monitoring. Gallery forest is being cut at a great rate and as Fish Eagles rely on trees to perch on whilst hunting (Eltringham 1975), the effect on eagles of loss of trees may be great. Fish Eagles as a top predator feeding on fish, birds and large mammal carrion, are likely to be directly affected by the health of these populations. A stable or increasing population of Fish Eagles therefore indicates that fish stocks are healthy. Fish Eagle populations should be monitored as is the case with other large raptors in this valley to assess the effects of man's activities on the local ecology.

Overall the Kilombero Valley is of international importance for three species of waterbirds (Openbill Stork, White-crowned Plover and African Skimmer) and probably for at least four others (Yellow-billed Stork, Wattled Plover, Common Pratincole and Water Thicknee). The valley may be found to be of some importance for Palaearctic migrants but so far we have no evidence to indicate this. Surveys of species found on grassland and coverage of those rivers not surveyed in this study could lead to other species being found in important numbers. Local Sukuma herders showed interest in and recognition of an illustration of the near-threatened Shoebill Stork *Balaeniceps rex*. The habitat in the valley is not totally suitable for this species but given its ability to travel quite large distances it could possibly be a wandering migrant to the valley.

Kilombero Weaver Ploceus burnieri

Introduction

The Kilombero Weaver was first discovered in 1986 in a small area of the floodplain in the vicinity of the Kivukoni ferry (Baker & Baker 1990). It has subsequently been found further upstream towards the centre of the valley (Baker & Baker in prep.). Very little is known of its ecology. It has been observed feeding on flowering and fruiting heads of reeds and on the ground in unflooded areas (Baker & Baker 1990). It weaves its nests in colonies of up to 30 pairs on reed *Phragmites mauritianus* stems.

Distribution and ecology

The Kilombero Weaver was found to be very common within the valley in areas away from trees and close to water (Figure 2.1). The weaver is found the full length of the valley, being found close to Malinyi in the south along the Mnyera River and some were observed just inside the Selous Game Reserve in the north-east. These latter records are the first records of *Ploceus burnieri* for the Selous G.R. It was rarely seen away from *Phragmites mauritianus* reeds and therefore its distribution may be restricted to that of *P. mauritianus* reeds. It may therefore have a patchy and very restricted distribution within its total range. It was seen only once in an area with trees. This is possibly related to competition from the Golden Weaver *Ploceus subaureus* which is found in wooded areas close to water within the valley. It is also possible that the small area of reeds close to wooded areas is limiting the distribution although this is not likely as these areas are scattered around the valley.

P. burnieri's scores in TSCs were low, scoring 1 in short grass and 0.1 in long grass. This may reflect its restriction to areas with reeds and perhaps its tendency to flock during the non-breeding season (a large flock will score the same as a single bird) or actual low density. Mist-netting targetting *burnieri*, which was carried out close to reeds, caught *burnieri* as frequently as Fan-tailed Widowbird *Euplectes axillaris* although this work was not systematic. ***Burnieri* therefore appears to be abundant in it's preferred habitat. It is also apparent that *burnieri* is genuinely restricted to areas close to reeds and is scarce away from these areas**.

Baker & Baker (1990) state that from their experience in other areas, *subaureus* would be expected to utilise the swamp habitat in the central Kilombero Valley floodplain. However, *subaureus* was only seen in wooded areas and in bamboo *Arundinaria* in Ifakara (it was also recorded in this bamboo by Baker & Baker (1990). It is therefore possible that competition is playing a part in restricting the distributions of *subaureus* and *burnieri*. When observations of the two weavers when plotted together on the same map their distributions are effectively exclusive (Figure 2.1); *burnieri* being almost completely surrounded by *subaureus*. *Burnieri* could possibly expand its range as gallery forest and other trees are cut down in the floodplain and feeder rivers for agriculture and fuel wood. This would be at the expense of *subaureus* which feeds more often in trees than *burnieri*. However, considering how limited the distribution of this species is in the valley there are probably other factors limiting its distribution beyond that of absence of trees. There is a possibility that the Kihansi dam in the mountains in the south-west may alter the flooding regime in the valley (see general conservation section) and if this was severe then it is possible that *subaureus* could invade the central floodplain if trees and bushes were able to grow. This competition could cause serious problems if *subaureus* limits the distribution of *burnieri* to areas free of trees.

Breeding

This species was not observed breeding at this time of year (July-September) and very few birds were seen in breeding plumage. Therefore they presumably breed during the wet season only; Baker & Baker (in prep.) have found them probably breeding from January to April. The availability of good quality food from reed heads could perhaps be limiting at other times of the year.

Evolution

Baker & Baker (1990) comment on the small size of *burnieri* compared to other swamp/waterside weavers and suggest that this may be due to lack of interspecific competition through isolation, *subaureus* probably being a more recent arrival in the valley. They suggest that *burnieri* being small would be unlikely to be able to displace *subaureus* from its habitat and so would be unable to use wooded sites on the edge of the floodplain. This is possible, however, I think that potential nest sites (*P. mauritianus* reeds) are much more numerous in the valley relative to food availability and therefore this hypothesis may be unlikely. The small size of *burnieri* may be an evolutionary adaptation to the need for increased agility when feeding on reed flower and seed heads and may not be related to interspecific competition.

Behaviour

It was observed perching or resting on open ground, man-made shelters (fish smoking racks, wooden huts), reeds and *Panicum* grass. The most surprising observations of this species were its use of artificial habitats. The place where it can be seen most easily is behind the shops at Kivukoni ferry where it can be seen feeding on human refuse (cooking waste, litter from shops, etc.). I was not able to see what specific items it was eating but no large items were picked up and carried off. However, on 15/7 a number of birds in non-breeding plumage were observed feeding on fish which had been smoked at a temporary fishing camp. The birds entered the covered smoking platform and pecked at the fish. Their behaviour at this fishing camp and at Kivukoni was analogous to that of House *Passer domesticus* and Grey-headed Sparrows *P. griseus*. These latter two species are probably unable to breed in the floodplain because of the absence of permanent buildings for suitable nest sites as the valley floods during the wet season. Their nearest breeding sites are generally at least 5 kilometres away from most parts of the floodplain.

The survival of *burnieri* during the floods must depend on its ability to feed on reeds, the only emergent vegetation in the valley at this time. The flower heads and seeds will be the only food for this species as most land and human habitation will be flooded so little spilt grain or refuse will be available. Fish-smoking and other human activities will be restricted to the edges of the valley on higher ground.

Conservation

Construction of any permanent buildings within the floodplain is unlikely because of the flooding but if House or Grey-headed Sparrows became established there, then they could compete with *burnieri*. The loss of gallery forest around the valley will almost certainly allow *burnieri* to increase its range and is therefore of little concern for this species. It is possible that *burnieri* could be down-listed to near-threatened as its area of occupancy has been found to be quite large. However, it has a restricted distribution within this area as it is only found in proximity to *Phragmites* reeds and it appears to be found at a low density. Also the Kilombero Valley is being rapidly altered by the rapidly increasing human population, large-scale agricultural expansion and possible change in flooding regime (see general conservation section). Therefore it should remain listed as vulnerable.

Cisticola species

Cisticola No. 1

This putative species was first discovered by Neil and Liz Baker (1990) close to Kivukoni at the time the Kilombero Weaver was discovered. Very little was known of this bird other than that it is a duetting species.

This species was found throughout the valley in a wide number of locations (Figure 2.2), although there were difficulties in identification at first (being a Cisticola) Once the song had been recognised this enabled it to be identified more quickly. It was found in thick vegetation such as long grass, reeds and in floating papyrus Papyrus at Kibasira swamp. TSC scores are high for three habitats: 2.75 (swamp), 2.1 (long grass) and 2.4 (short

grass). However, as its call is distinctive and far-carrying it may have been found at the edges of some of these habitats. The distribution map (Figure 2.2) suggests that it has quite broad habitat requirements, being found from the centre of the valley to close to Mofu, a village situated near the edge of the floodplain. However, it was generally found in areas close to water, a feature not shown by this basic map. It also appears to be found close to open areas, although it was not often seen in the open area itself. The song was recorded at a number of sites including close to Mofu. On the recording from this site it can be heard singing with cockerels crowing in the distance suggesting that habitat alteration such as scattered fields may even benefit this species by creating cleared areas. However, complete loss of tall grass or reeds could be expected to be strongly negative.

It was heard singing throughout July, August and September although similarly to the Kilombero Weaver it was fairly localised. Again, this could be related to its preference for waterside habitats which were less well represented in our TSCs than drier habitats. This species would be most easily censused by noting singing pairs. Transect counts could allow population estimates to be made instead of the relative abundance obtained by TSCs. This would be valuable for a species which will be threatened or near-threatened when described.

Cisticola No.2

This putative species was also discovered by Neil and Liz Baker (1990) at Kivukoni when they discovered the Kilombero Weaver. Very little indeed was known about this species.

Our survey found this species occasionally but on the whole it appeared to be less common than the previous species. For example, it was not recorded during the TSCs. This is probably because it was not singing during the period of our stay and as a result it would have been relatively inconspicuous. Identification was also a problem. It was observed carrying food on 15/7 which may indicate that it was breeding at this time (it may possibly stop singing after egg-laying). There were a number of observations of this species throughout the valley from the centre of the floodplain to the edge of the valley. It was also recorded from the edge of the Kibasira swamp where a dead individual was found. The distribution can be seen in figure 2.2.

Conservation status of the cisticolas

The difficulties in identifying these species, especially Cisticola No.2, have caused problems in our attempts to assess the status, ecology and distribution of these two species. Under the threat definitions of the IUCN (1996), Cisticola No.1 because of its restricted distribution (found only within the 5000 sq km valley) but relatively high abundance can be given the threat status of near-threatened. Its area of occupancy is greater than 2000 sq km so it may not be regarded as vulnerable. Unlike the Kilombero Weaver it is found in a range of habitats and does not appear to be limited to a particular plant species. Cisticola No.2, however, was poorly covered by this survey and because only basic knowledge on its ecology and distribution was collected, it is probably best to record this species as insufficiently known (Data Deficient, IUCN 1996).

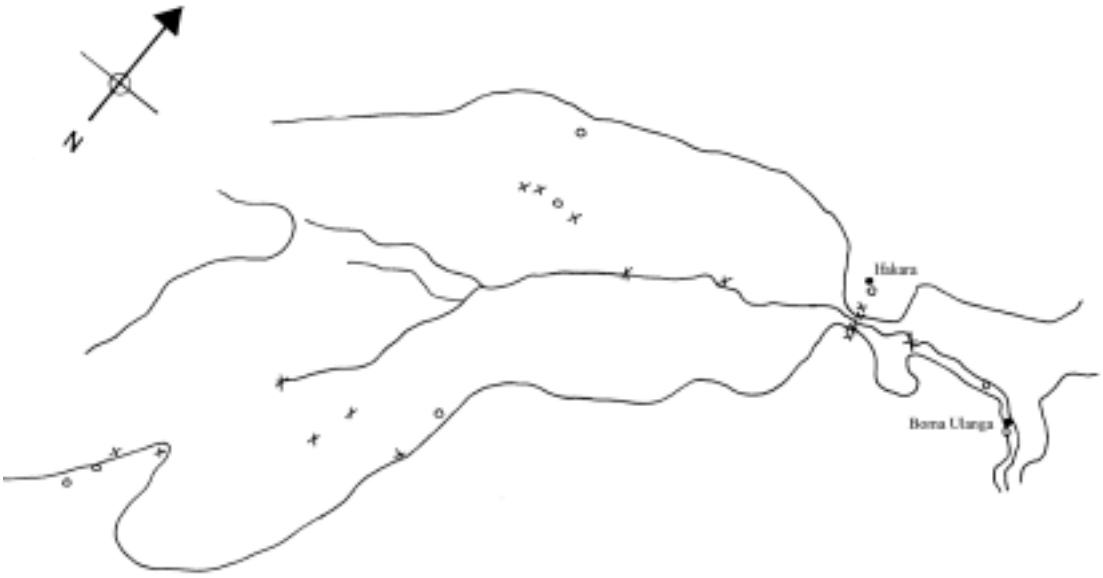

Figure 2.1 Map of the distribution of the Kilombero Weaver *Ploceus burnieri* (X) and the Golden Weaver *Ploceus subaureus* (O). Note how *P.subaureus* barely enters the floodplain and surrounds *P. burnieri* on all sides.

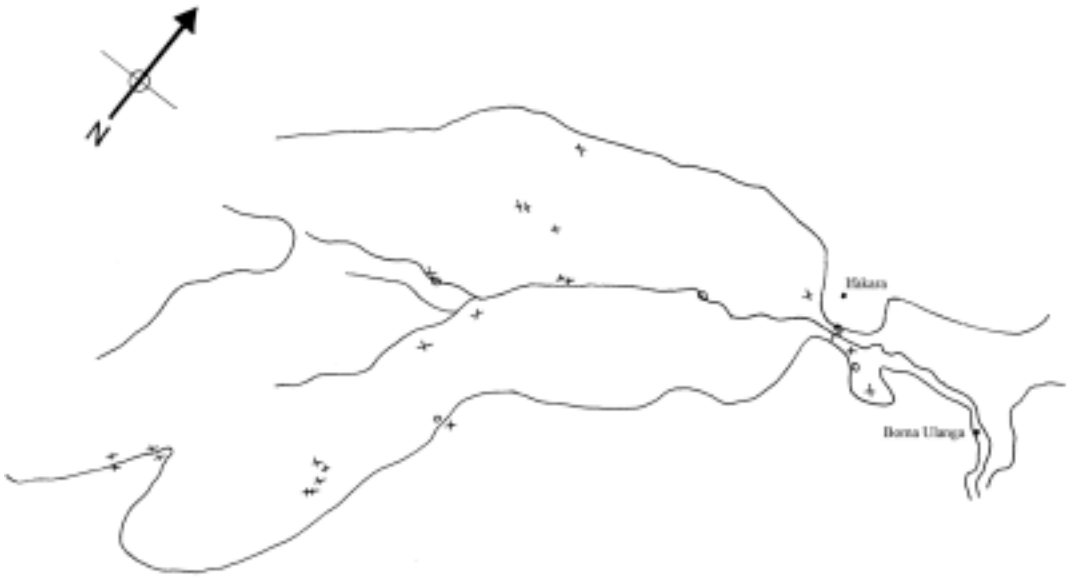

Figure 2.2 Map of the distribution of the two putative species of Cisticola.. Cisticola No.1 (X) and Cisticola No. 2 (0).

Bird community surveys

Introduction

The bird community survey was an important part of this bird project as the use of different habitats by the endemic and threatened species of the Kilombero Valley was not known. The avifauna of the valley is known to be an unusual combination of lowland and highland species and it also includes a large number of biome-restricted species (Baker & Baker in prep.). Our survey intended to show the relative importance of each habitat for different species

Methods

Timed species counts (TSCs) were carried out to compare bird communities in different habitats using the method described by Pomeroy & Tengecho (1986a, see also Bibby *et al*. 1998). This method is based on the assumption that common birds are on average more likely to be seen first and rarer birds may take longer to find. A counting period (usually one hour) can be divided into six periods and a species scores 6 if it is found in the first period, 5 in the second, 4 in the third and so on. This method should ideally be repeated 10-15 times for each habitat and a mean score across all one-hour counts for each species can be calculated. The maximum that any species can score is therefore 6. The majority of the timed species counts were carried out at the same time as the large mammal censuses as this allowed economy of effort, especially with regard to logistics. Only in wooded short grass areas were TSCs found to require a slower pace than the mammal surveys, and this was not the case at all times. In fact, with increasing observer skill at identification, this ceased to be a significant problem.

TSC surveys were carried out in five habitat types:

Short grass

This is generally a distinct zone with low vegetation usually between the long grass and wooded short grass habitats towards the edge of the floodplain. Vegetation was usually below knee height. This habitat becomes inundated to a varying extent in the wet season. The grass length is probably closely related to the grazing pressure; the short grass areas being used extensively by wild herbivores and domestic livestock. These areas are probably burnt more often as there is more human activity because of grazing and most fires are lit artificially. There are many small areas of short grass within the interior of the floodplain but these tended to be patchy and were not included in this category for TSCs.

Long grass

Most of the interior of the floodplain is dominated by long grasses such as *Panicum* (see plant report). This habitat was often composed of continuous stands of grasses above two metres in height which made bird surveys very difficult. However, there were patches of short grass created by grazing herbivores such as Buffalo *Syncerus caffer* and Puku *Kobus vardoni*. Long grass areas were also by definition less likely to have been burnt. Movement was quite difficult but the habitat is extensive and so it was important that it was surveyed.

Wooded short grass

Open woodland, often with distinct boundary between trees and short grass as a result of fire. This habitat is under the most pressure from man as a result of over-grazing, wood-cutting and clearance for agriculture.

Swamp

Inundated areas with thick vegetation. These swamps tended to be at the edge of the floodplain and contained trees. Therefore they probably differ greatly in their avian community composition. Movement was

very difficult and only possible along paths cleared by Elephants *Loxodonta africana*. Because of this only four TSCs were possible in this habitat. It was not possible to carry out TSCs in Kibasira swamp because of the very thick vegetation, deep water and Hippopotamus *Hippopotamus amphibius*.

Wooded long grass

Moist open woodland with grass above two metres in height. Movement also difficult and again made possible by using Elephant and Buffalo paths. This habitat was quite limited and this factor, with the difficulties of movement meant that only two TSCs were possible in this habitat.

Working from the river at the centre of the valley to the edge of the valley, generally the natural habitat succession runs as follows:

River
Reeds Phragmites
Long grass
Short grass
Wooded short grass
Wooded long grass or miombo *Brachystegia* woodland
Forest (along small streams) or miombo

Swamp could be found in any area. Cultivation was most frequently found in wooded short grass or short grass areas. See plant report for more details of habitats.

Results

In total 108 species were recorded during the TSCs. Scores for individual species in the TSCs are given in appendix 3. This total, as a proportion of the total known species from the valley (372 species, see appendix 4), indicates how appropriate this technique is. Histograms for frequency of scores for each habitat are given below. They give an indication of the completeness of the survey, ideally the frequency curve should be smooth. When a large number of surveys have been carried out an assessment can be made of the overall species diversity. Comparisons of individual species TSC scores are shown for a number of closely related species where the species have been found to be numerous enough for a meaningful comparison.

This technique allows relative habitat use to be assessed for some of the more common species that were recorded. Species pairs within which there may be competition can be shown to reduce this potential problem by using different habitats. This can be seen for waders such as White-crowned and Wattled Plovers as well as more common species such as doves and weavers (Figs 2.7-2.9). This may be of future value in understanding future population changes as a result of habitat degradation by man or a change in flooding regimes.

By plotting the number of new species recorded in a count against the log of the cumulative total of species recorded up to and including that count the number of species remaining to be recorded can be estimated. Extending the trend line through the points to the y-axis allows the intercept to be converted into a species total. This is a more accurate way of predicting total species numbers in a habitat than estimating by eye from an extended species accumulation curve. This can then be used to predict the number of species yet to be recorded in this habitat during the same conditions using the same survey technique. Figures 2.10-2.13 show how this is carried out for the different habitats and they also indicate the possible validity of this process if the number of counts is low. For example, only four surveys in swamp were completed and therefore it may be more dangerous to make predictions about the total number of species in the habitat.

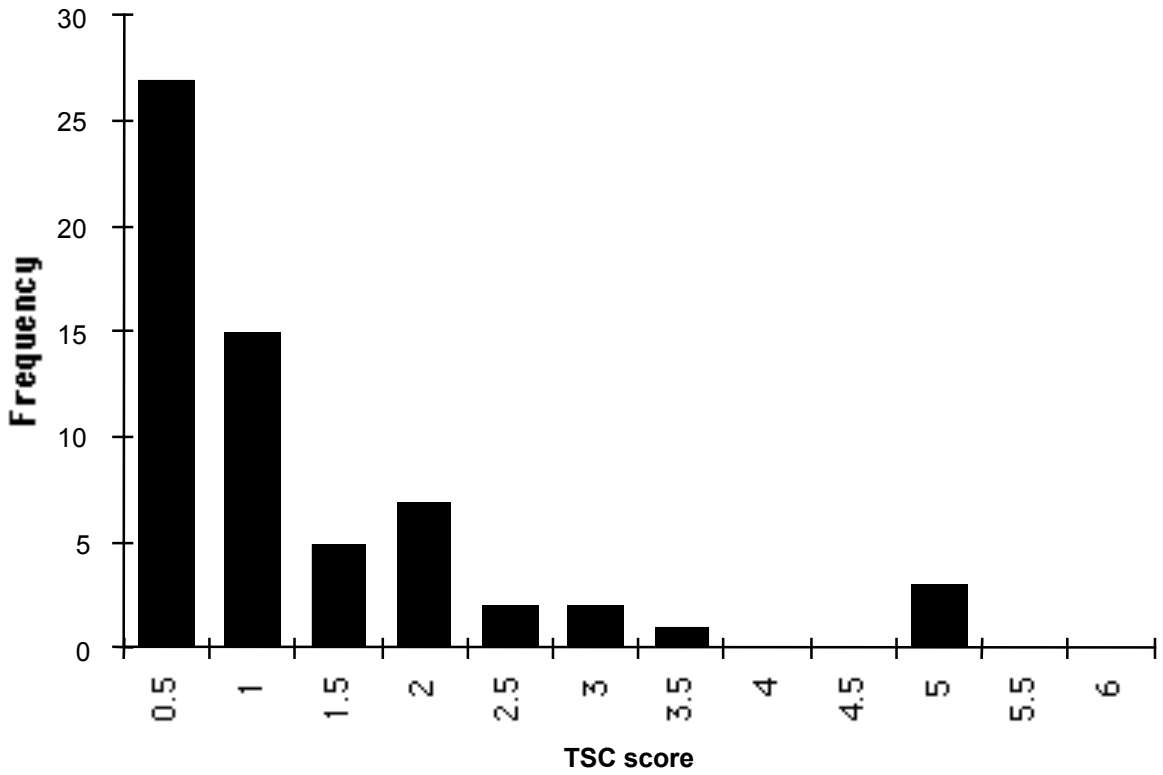

Figure 2.3. TSC score frequencies for wooded short grass (n=6).

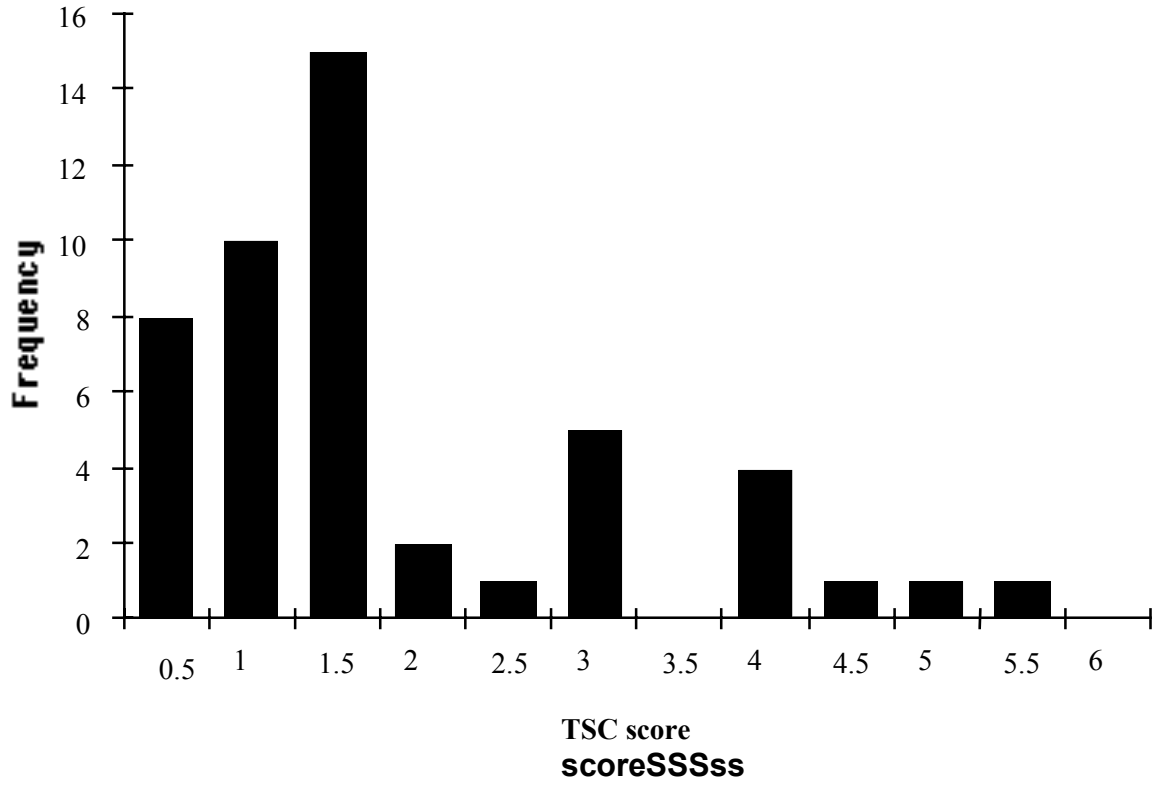

Figure 2.4. TSC score frequencies for swamp (n=4).

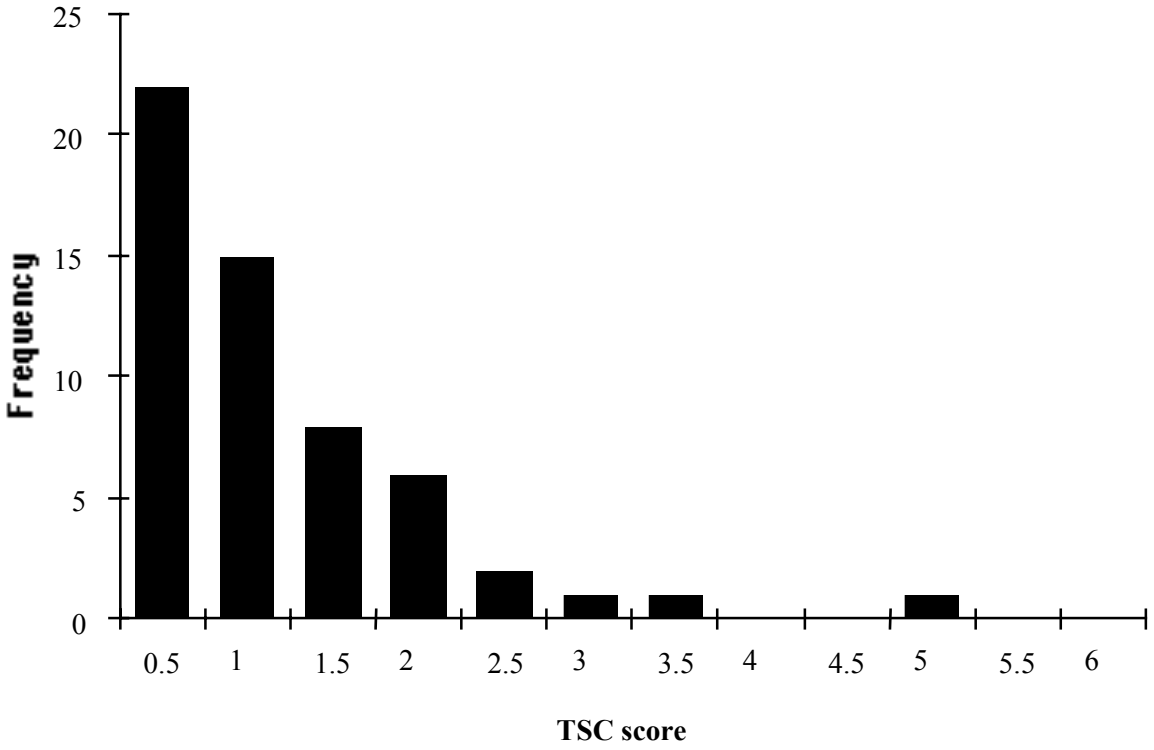

Figure 2.5. TSC score frequencies for long grass (n=10).

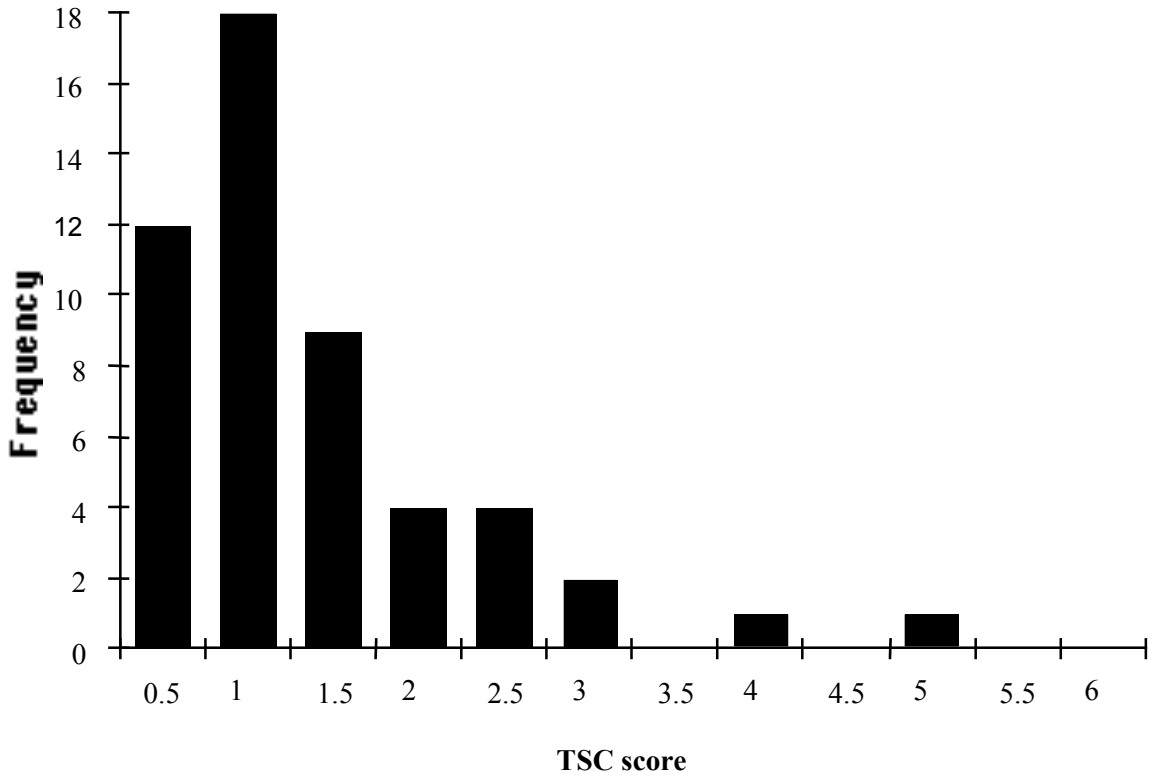

Figure 2.6. TSC score frequencies for short grass (n=7).

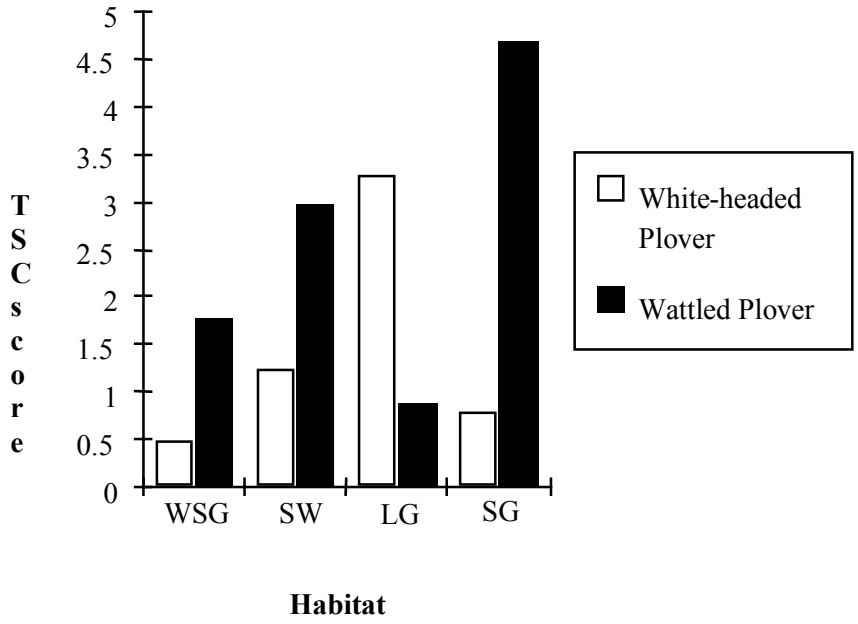

Figure 2.7. Use of different habitats by White-crowned and Wattled Plovers using TSC data. Wattled Plover was found to use some habitats significantly more than others (p=0.032, F=3.49). White-crowned Plover showed no significant difference in use of habitats. It is possible that an increase in the number of TSCs carried out would show that there were differences in habitat use by White-crowned Plovers. WSG-wooded short grass; SW-swamp; LG-long grass; SG-short grass. White-crowned Plovers used long grass significantly more than Wattled Plovers (t-test, p=0.046). Wattled Plovers used short grass significantly more than White-crowned Plovers (t-test, p=0.0082).

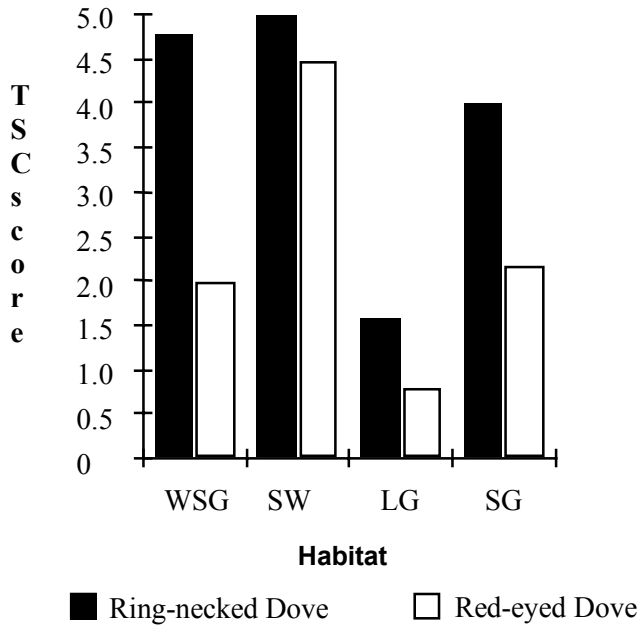

Figure 2.8. Ring-necked Doves showed significantly more use of some habitats than others (p=0.036, F=3.36). Red-eyed Dove showed no significant variation in habitat use.

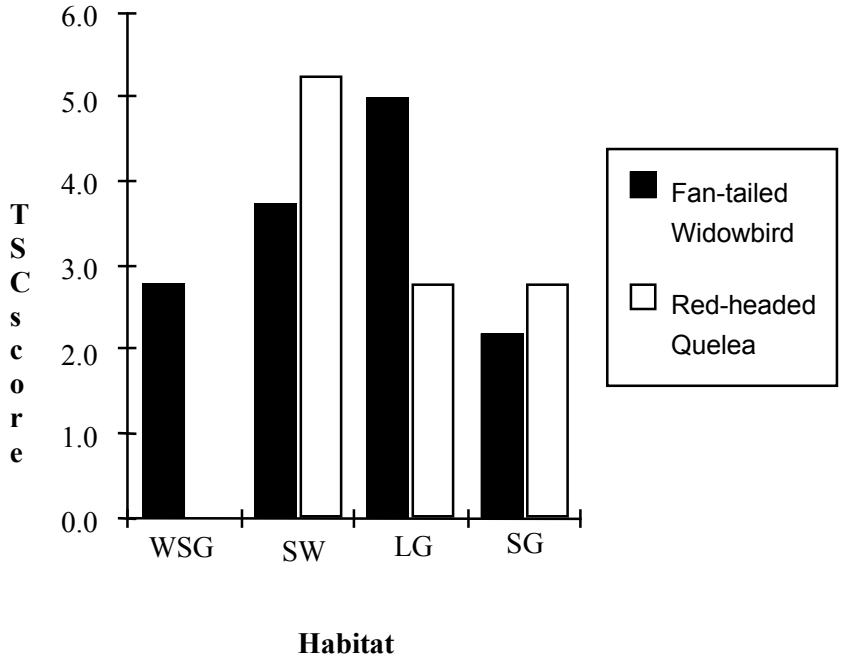

Figure 2.9. Red-headed Quelea used some habitats significantly more than others (p=0.028, F=3.61), whereas Fan-tailed Widowbird did not.

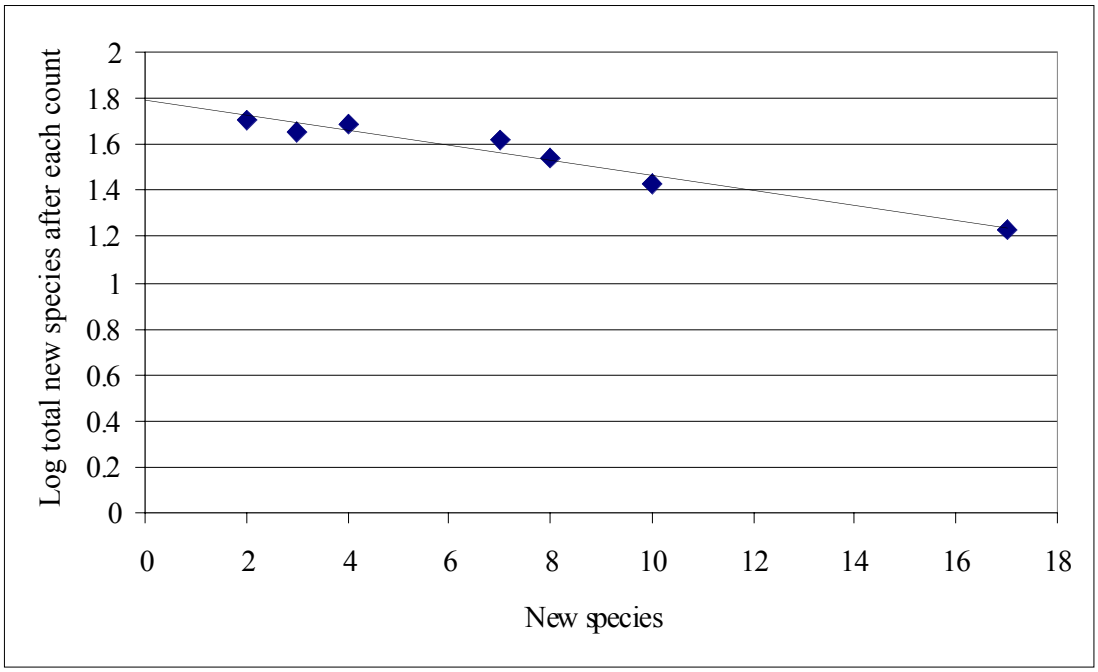

Figure 2.10. Log cumulative species recorded during TSCs after count *i* against new species recorded at count *i* for short grass habitat. y = -0.0325x + 1.7914. R^2 = 0.9557.

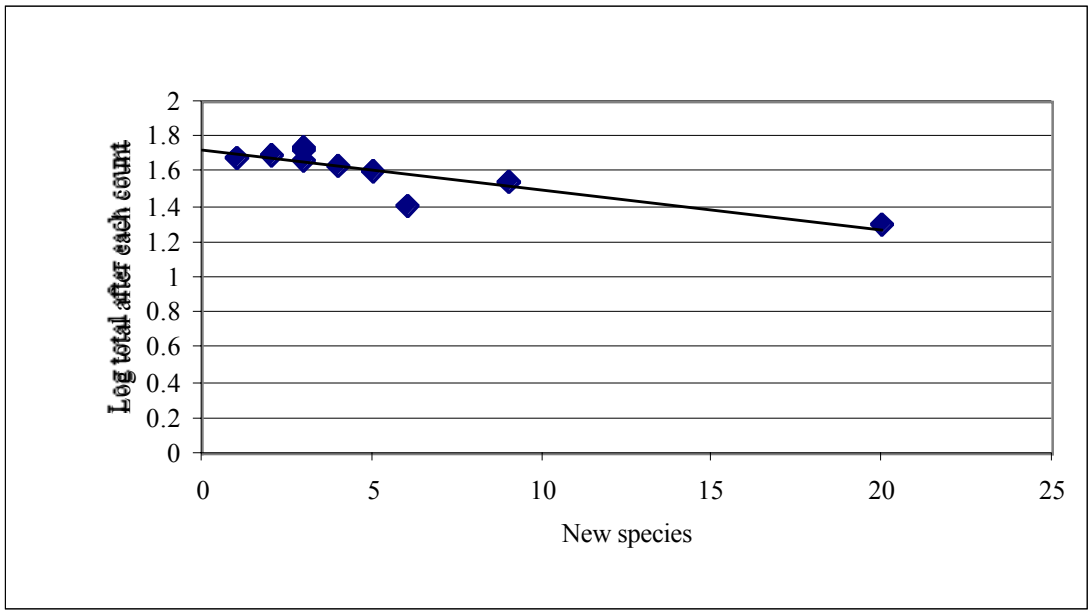

Figure 2.11. Log cumulative species recorded during TSCs after count *i* against new species recorded at count *i* for long grass habitat. y = -0.0227x + 1.73. R^2 = 0.7574.

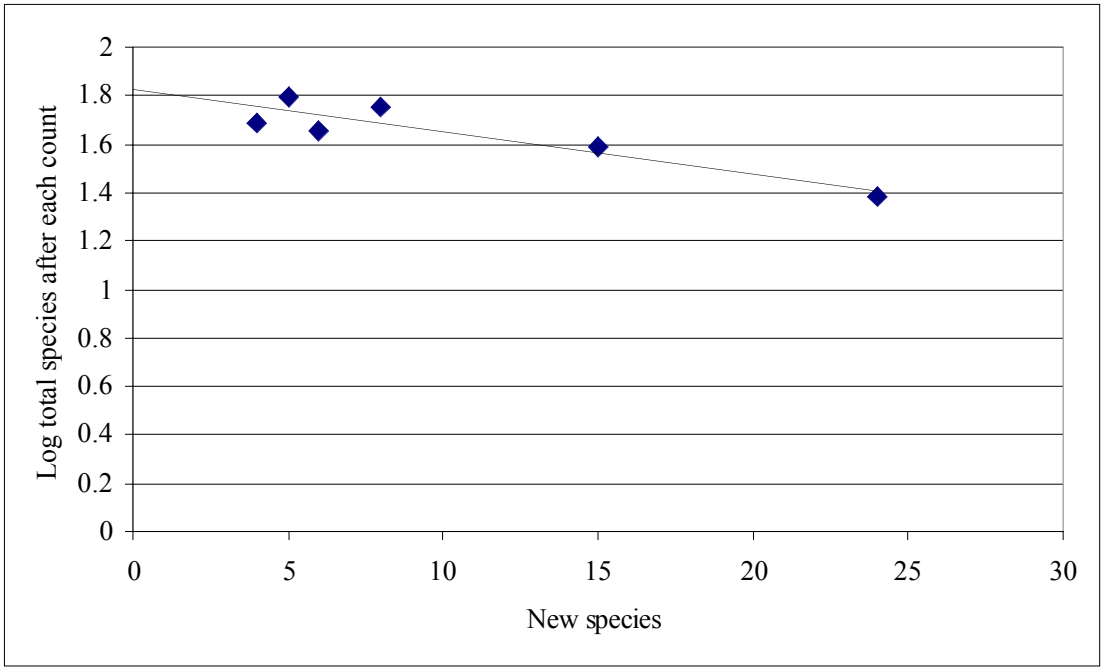

Figure 2.12. Log cumulative species recorded during TSCs after count *i* against new species recorded at count *i* for wooded short grass habitat. y = -0.0174x + 1.8234. R^2 = 0.834.

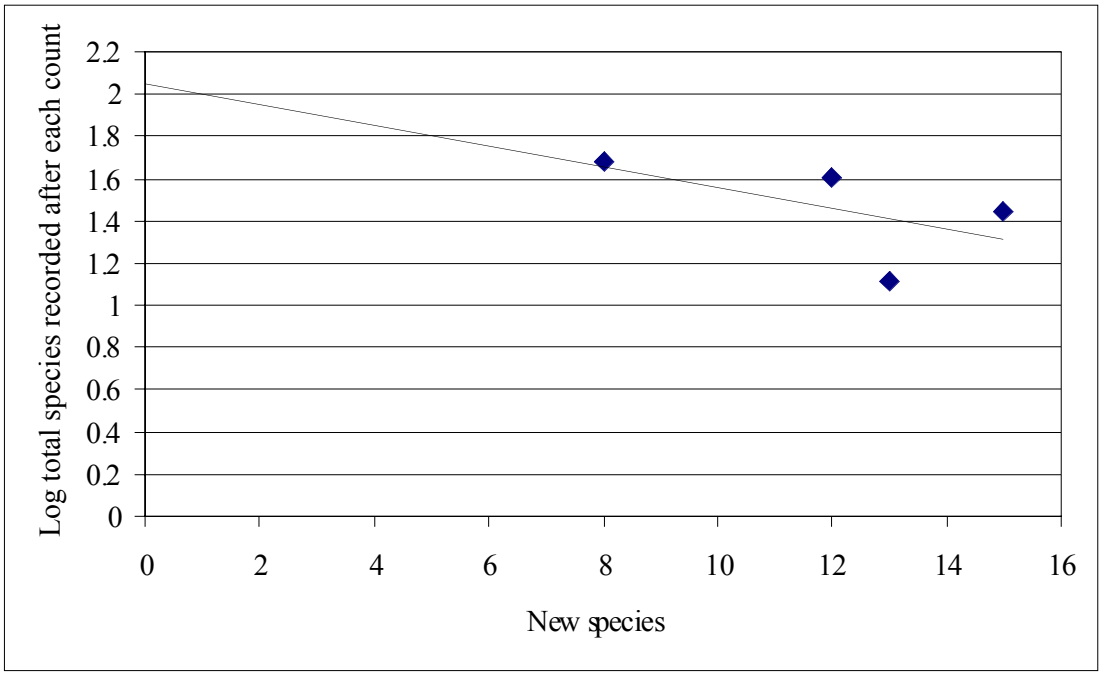

Figure 2.13. Log cumulative species recorded during TSCs after count *i* against new species recorded at count *i* for swamp habitat. $y = -0.0488x + 2.047$. $R^2 = 0.3279$.

Discussion

The presence of six threatened and near-threatened species is of great interest as is the presence of a great number of biome restricted species (Tables 2.3 and 2.4). Both show the importance of the valley for birds and the quality of habitats for birds. The number of species recorded during timed species counts (Figure 2.14) is pleasing and gives an indication that it is an effective technique for community bird surveys. The curves for the TSC score frequencies for wooded short grass (Figure 2.3) and swamp (Figure 2.4) indicate that many more surveys are needed in these habitats to produce accurate scores for all species. The species accumulation curves for these two habitats also confirm this (Figure 2.10). The annotated species list in appendix 2 gives a more detailed discussion of the most interesting results.

Table 2.3. Threatened species in the Kilombero Valley.
Threat status for the two cisticolas is provisional until they are described.

Species	Status
Kilombero Weaver	Vulnerable
Madagascar Squacco Heron	Near threatened
Southern Banded Snake Eagle	Near threatened
Stierling's Woodpecker	Near threatened
Cisticola No.1	Near threatened
Cisticola No.2	Insuffic. known

Table 2.4. Biome assemblage species recorded in the Kilombero Valley.

Brachystegia biome
Dickinson's Kestrel
Coppery-tailed Coucal
Boehm's Bee-eater
Racquet-tailed Roller
Pale-billed Hornbill
Stierling's Woodpecker
Miombo Rock Thrush
Cisticola No.1
Cisticola No.2
Rufous-bellied Tit
Shelley's Sunbird
Broad-tailed Paradise Whydah
Kilombero Weaver
East African Coast biome
Southern Banded Snake Eagle
Brown-headed Parrot
Green Tinkerbird
Fischer's Greenbul
East Coast Batis
Uluguru Violet-backed Sunbird
Black-bellied Glossy Starling
Zanzibar Red Bishop

The habitat data is of great value as previously, use of drier habitats by White-crowned Plover was not well known. The comparative nature of this work is also of value and we hope that future surveys will add to this. It may help in understanding the ecology of the different species and any change in population status. This is especially valuable considering that usage by humans of these habitats will increase and over-grazing, especially is likely to become quite severe.

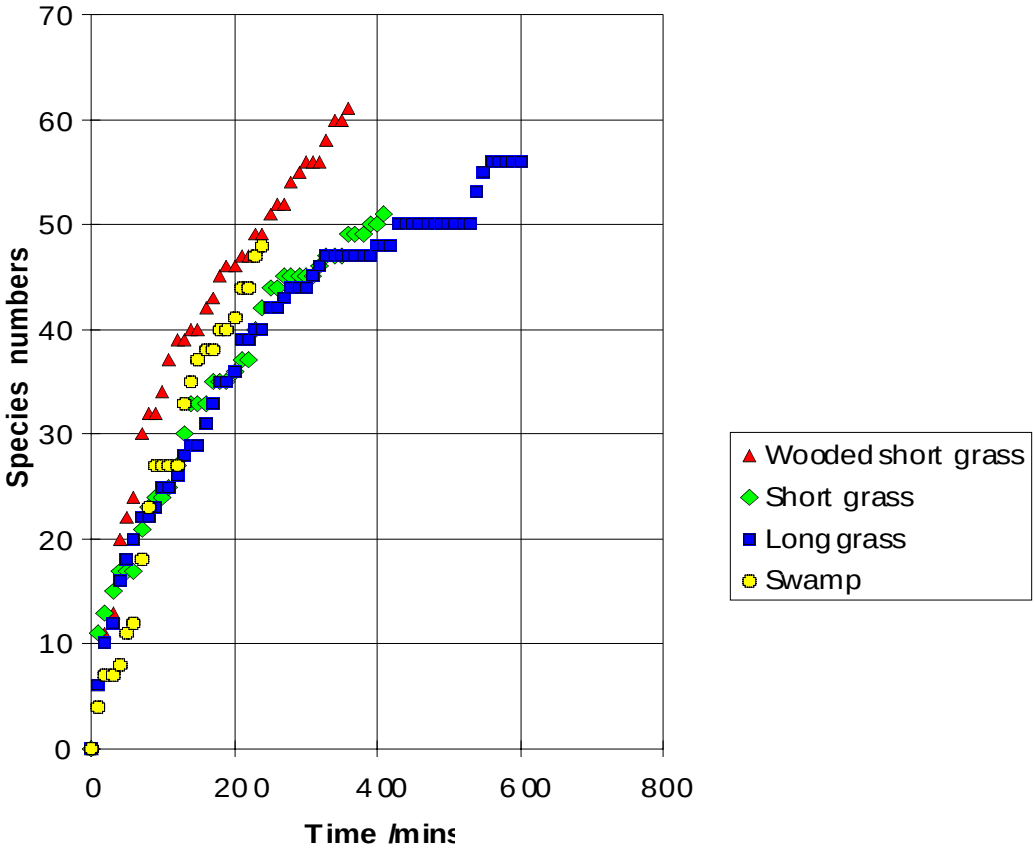

Figure 2.14. Species accumulation curves for different habitats during Timed Species Counts

Conservation of the birds of the Kilombero valley

Conservation status of the valley

The Kilombero Valley is undoubtedly of great importance for birds. It has a unique bird community which is, using the definition of BirdLife International for an important bird area (IBA), 'of international significance for the conservation of birds at the global level'. An IBA can be designated if a site meets any one of the criteria given by Fishpool (1997). The Kilombero Valley meets all four relevant criteria. The components of its avifauna which meet the criteria are listed as follows:

Threatened species

It contains one recently described weaver which is endemic to the valley and a further two putative species which are likely to be described in the near future. These all have a restricted range. The Kilombero Weaver is already regarded as vulnerable and judging from the data collected in this study it should remain so. One cisticola is more common than the weaver and is found in a wider range of habitats and should therefore be listed as near-threatened rather than vulnerable. The other cisticola is too poorly known, in part because of difficulties in identification and should be listed as data deficient. Three other near-threatened species are also found within the valley: Madagascar Squacco

Heron, Southern Banded Snake Eagle and Stierling's Woodpecker. The valley is obviously of considerable importance for threatened species.

Endemic species

Currently the valley is regarded as a secondary endemic bird area because of the presence of the weaver but as soon as either of the cisticolas are described then the valley will become an endemic bird area (an area containing two or more species with ranges less than 50,000 sq km) (Stattersfield *et al*. 1997).

Biome-restricted species

The valley contains 21 species which have distributions restricted to a particular biome. 8 species are from the East African Coast biome-restricted assemblage and 13 species are from the Brachystegia biome-restricted assemblage (Fishpool 1997). This high level of representation of two groups of species is an indicator of the quality of the habitats within the valley.

Congregatory species

Three waterbird species have been found in important numbers: Openbill Stork, White- crowned Plover and African Skimmer. A wetland may qualify as an important bird area if a site holds or is thought to hold 1% of a biogeographic population of a waterbird on a regular basis. African Skimmers were also counted in important numbers in 1995 and it is very likely that other species including Common Pratincole and Wattled Plover as well as the above species are also found regularly in the Kilombero Valley in important numbers.

The Kilombero Valley meets all four of the criteria for an important bird area. This is likely to be one of the few places in Tanzania to meet all criteria for an important bird area. This valley is of great international significance for birds. Furthermore, the high total of 373 species (see appendix 4) known from valley is impressive considering its small size (5,000 sq km) and the relatively uniform habitat throughout much of floodplain. This is partly a function of its position between the vast miombo woodlands of the Selous Game Reserve and the forested highlands of the Udzungwas.

Threats to biodiversity

Habitat loss is the greatest threat to most species throughout the world and this is so for many species in the valley. The Kilombero Weaver and the two new cisticolas will probably not be affected by loss of reeds or tall grass as they are common throughout the valley. However, a change in the flooding regime could alter the habitat used by these species. If this was drastic it could even allow the Golden Weaver to outcompete the Kilombero Weaver in the central floodplain. At present this scenario is unlikely, but as the environmental impact assessment of the effects of the Kihansi dam was inadequate because it only investigated the forests of the Kihansi gorge rather than the floodplain at the foot of the gorge, we cannot be sure.

Similarly the Kilombero Sugar Company north of Ifakara is planning to triple production in three years (Anon 1998). This same source also states that the managing director of the Kilombero Sugar Company views the area as having 'considerable expansion potential'. The endemic birds have not been recorded north of Ifakara but they have been found north of Kivukoni and would almost certainly be affected by any major agricultural operations, especially as these would be likely to include use of chemical sprays. Grassland birds such as Wattled and White- crowned Plovers would be most at risk from this project. This new development is worrying because of our almost total lack of knowledge of the birds north of the Kilombero River within the valley. Rice projects seem to be a minor threat at the moment but should be monitored.

Important bird area boundaries

The boundaries of any site for the purposes of conservation should be as clear as possible and should allow the site to be as easily managed as possible whilst maintaining the integrity of the site and its wildlife. The designation of a site as an important bird area (IBA) should follow these guidelines. It is recommended that wherever possible, IBAs should include existing protected area networks (Fishpool 1997). The Kilombero Valley is almost entirely within the Kilombero Game Controlled Area, the boundaries of which are poorly known. We would like to propose that the boundaries of the Kilombero Valley IBA are clearly signposted for the purposes of aiding wildlife managers and conservationists.

The main boundaries of the IBA should follow the main roads running along the sides of the valley. On the south-east side this should start at Lupiro and follow the road south-west to where the road (now a path) runs west of Malinyi on the UTM gridline 09010. At Lupiro, the IBA boundary should run directly east of Lupiro to the Selous G.R. border. The northern boundary should start on the UTM gridline 09120 at the Selous G.R. border and run west to where it meets the road running alongside the valley. The IBA should run south-west following the road to where it meets the gridline 09010. These boundaries should ensure that the majority of the habitat of waterbirds and endemic birds are included as well as linking the valley and the Udzungwa Mountains National Park (NP), the Selous GR and the forest reserves (Nambinga, Nyanganje, Ihanga, Matundu) around it.

Conservation management

Management of the valley should be co-ordinated for all species. Responsible management of large herbivore populations will almost certainly allow conservation of all other taxa. The valley's location is ideal for wildlife and ornithological safaris as it lies close to three large protected areas: Mikumi NP, Udzungwa Mountains NP and the Selous GR. The ease with which the interior of the valley and the river can be entered should also encourage tourism. The development of the road to the valley, whilst likely to be negative in general conservation terms should be used in part of the drive to encourage tourists to enter the valley. The presence of five endemic and threatened species (Udzungwa Forest-partridge *Xenoperdix udzungwensis*, Rufous-winged Sunbird *Cinnyris rufipennis*, Kilombero Weaver and two cisticolas) within such a small area should be of great interest to many bird-watchers planning their travel. Similarly the presence of large herds of Puku, Buffalo and Hippopotamus will attract tourists. Small good-quality safari camps would be an important addition to these tours. Tour guides could be encouraged to visit the area for a number of days and to make use of local boatmen and other workers to encourage interest in the wildlife of the Kilombero Valley.

Recommendations for future work

Many of these suggestions have been made previously during the main text of this report but for ease of reference they are collated here.

Quantitative grassland bird surveys*,* primarily for White-crowned and Wattled Plovers and Common Pratincole as all three species were found to be common on grassland. The White-crowned Plover is already found in important numbers and the Wattled Plover and Common Pratincole would probably be found in important numbers if grassland counts were made. This survey could also be useful for assessing the value of grassland for other species such as Saddle-bill Stork, herons and Senegal Plover.

Gallery forest and low altitude forest surveys, to assess their use by forest species during both cool and warm seasons. A number of highland forest species such as Orange Ground Thrush and White-starred Forest Robin *Pogonocichla stellata* use gallery forest surrounding the Kilombero Valley probably during their altitudinal migration from the Udzungwa Mountains and Mahenge Highland. Links between highland and lowland forest, many of which are along gallery forest must be very important for migratory species which escape the cool, dry season in the highlands. The Amani Sunbird *Hedydipna pallidigastra*, a Vulnerable species recorded from the 1500 m in the Udzungwa Mountains, is found at sea level in Kenya and in mountain foothills in the Usambaras (Dinesen *et al.* 1993, Collar *et al.* 1994). It is not yet recorded from the Kilombero, but Dinesen *et al*. (1993) suggest that it may be found in the low-mid altitude Matundu Forest Reserve adjoining the Kilombero floodplain in the north-west. This latter forest is one of the few in the region to have complete cover over a great altitudinal range. Funga forest (named by Liz and Neil Baker) (02630, 90970) is unprotected and probably because of its proximity to Ifakara is being exploited quite heavily for timber and dugout canoes. This will undoubtedly increase with the rising human population. Its inclusion within the Selous Game Reserve would not be difficult from a practical point of view as the surrounding area is little used by pastoralists and farmers because of tsetse fly. Few people venture into the forest, aside from illegal loggers. Many other uncommon species such as Pel's Fishing Owl, Giant Kingfisher and Boehm's Bee-eater are also found only in these habitats. Quantitative and species inventory surveys in Matundu F.R. and other lowland forests are especially important as although some are relatively intact many are being cleared very rapidly. At one point we had to end mist-netting in the gallery forest by the Ruipa River as the forest was being cleared a few metres from our nets. These surveys would allow comparison of the relative qualities of low and high altitude forest in the Udzungwas and of the lowland coastal forests. The vulnerable species Rufous-winged Sunbird was recorded in August 1982 (cool season) at 600 metres in Mwanihana (Stuart *et al*. 1987, Collar *et al.* 1994). There is every possibility that it could be found at lower altitudes, possibly in Matundu F.R. Similarly the vulnerable Banded Green Sunbird *Anthreptes rubritorques* found as low as 850 metres in the Udzungwas is also found at 250 metres in the Usambaras (Dinesen *et al*. 1993). As many East African Coast biome species such as Southern Banded Snake Eagle are found in the Kilombero Valley it is not beyond possibility that threatened coastal species may be found here.

Raptor survey, to produce an estimate of the size of the raptor populations of the valley. There are 37 species of diurnal raptor in the valley, a high number and species such as Bateleur and White-backed Vulture appeared to be very common. Surveys in different seasons would be useful as it is possible that more vultures and would be found in the valley when large herbivores from the Selous G.R. are within the valley. The inundated ground during the wet season could also affect the availability of some prey species. A suitable census technique for species in open habitats would be line transects, preferably dividing the transect area covered into belts. It could be possible to carry out this survey at the same time as a grassland bird survey and large mammal census which would allow for economy of effort. See Bibby *et al.* (1992) for more detailed techniques. Other more secretive species such as owls could be surveyed by listening for calls, play back, and mist-netting.

Miombo woodland survey. Our survey did not target species found primarily in miombo *Brachystegia* woodland. This habitat should be studied because the increasing human population, the large areas of teak plantation due to be planted and the development of the main road to the Kilombero Valley are placing it under increasing pressure. Many species typical of the *Brachystegia* biome, most notably the near-threatened Stierling's Woodpecker (see table 2.4), have been found during own survey and by previous observers and these can be regarded as indicators of the quality of the habitat. In fact, because of the known value of this habitat to large herbivores migrating to and from the Selous Game Reserve this habitat should be targeted for sympathetic management, especially where it extends from the highlands down to the floodplain itself such as at Madabadaba or near Mofu.

Kilombero Weaver breeding survey. A survey of the breeding distribution and density of the Kilombero Weaver should be carried out for this threatened species. This is especially important at the limits of its range (i.e. close to the Selous and downstream of Malinyi) where it nests close to Golden Weaver breeding sites as the nests can be difficult to distinguish unless birds are present. Attempts should also made to ring weavers to collect data on biometrics, moult, breeding activity and survival rates.

Waterbird censuses. The January and July-August waterbird censuses should be repeated (ideally annually) as part of the African Waterfowl Census to monitor the important populations of birds found here. This is particularly important for declining species such as African Skimmer and Madagascar Squacco Heron. The Msolwa River in the north of the valley (north of Ifakara) is unsurveyed and should be visited as soon as possible to assess its present value for waterbirds. The Kilombero Sugar Company has 6,400 ha of sugar cane plantations in the floodplain north of Ifakara. It is planning to expand to at least 10,400 ha and in the future possibly tripling its production. This would undoubtedly affect the Msolwa River. Observers unskilled in bird identification could attempt surveys of the more distinctive and important species such as African Skimmer, Fish Eagle, Giant Kingfisher, Finfoot, Openbill Stork, Goliath Heron and Hamerkop. These would be ideal for fisheries staff during their fish monitoring work.

Waterbird surveys of the smaller wooded rivers. Species such as Finfoot, Black Duck *Anas sparsa* and Giant Kingfisher which are uncommon (or as yet unobserved) and not well covered by surveys in the main floodplain would be important targets for such surveys. These rivers were not covered by our survey and there may be problems because of shallow water. However, rivers such as the Ruipa, Kihansi, Furua and Mnyera are quite large and it should be possible to navigate them by canoe. Surveys of this type could be combined with surveys of the extent of gallery forest clearing which would allow economy of effort. The Furua River appeared to be important for a number of species such as Finfoot and Openbill Storks as well as having high densities of crocodiles and bats. The Kihansi River is being modified upstream by the construction of the Kihansi Dam for hydroelectricity. The swamp forest there has not been surveyed and because of the work upstream this should be a priority for future bird surveys in the valley.

Assessment of the environmental effects of the construction of the Kihansi dam. The dam could cause changes to the flooding regime in the valley. If flooding was no longer as extensive in the valley a number of changes could take place. More trees and bushes could grow in the valley which may affect the competitiveness of the Kilombero Weaver against the Golden Weaver. The fish stocks in the valley could be reduced if they are unable to breed in the flood waters. This would also affect fish-eating birds and other wildlife. The overall production of the Kilombero fisheries would be reduced for the large human fishing population. Reduced flooding could allow more intensive and year-round agriculture in the valley. The reduced flooding could conversely reduce fertility as a result of lowered deposition of silt and this could cause further clearance of forests for agriculture. Reduced flow could alter the rate of change of channel creation by the flood waters. This could reduce the number of ponds and small channels thereby created and could pose problems for many species from the Hippopotamus to the Kilombero Weaver.

Further timed species counts should be carried out to produce more accurate estimates of relative abundance in different habitats for all species. This is especially important in the short grass and wooded short grass areas which are under pressure from agriculture and pastoralists. Environmental conditions within the Kilombero Valley will change throughout the year because of flooding and variation in rainfall and temperature. It is therefore useful to record the changes in avian community composition in the different habitats. We were only able to survey habitats during the dry season from July to September but in the future, surveys should be carried out in different seasons.

Cisticola surveys. Cisticola No.1 could be surveys using transects to count singing pairs. This work could be combined with the grassland wader surveys which would allow economy of effort. This method would provide population estimates or densities rather than just relative abundance provided by TSCs. Cisticola No.2 was not singing during our project but if the call was as distinctive then it would be possible to survey it using the same technique. Obtaining population densities, and thereby population estimates, is important for these species which are likely to be regarded as either threatened or near-threatened when they are described.

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Appendix 1: Water bird counts

Species	1995 count (Baker 1997)	1997 count (this study)	1% popn level for important species	TZ popn "guesstimates" (Baker 1997)
White Pelican	0	5		20,000-25,000
Pink-backed Pelican	9	49		10,000-20,000
Long-tailed Cormorant	26	64		50,000-80,000
Darter	6	22		<20,000
Little Bittern	1	1		c.10,000
Night Heron	2	4		5,000-20,000
Squacco Heron	104	66	500	10,000-20,000
Madagascar Squacco Heron	0	17	100	
Cattle Egret	46	665	10000	375,000-500,000
Green-backed Heron	2	84	1000	10,000-15,000
Black Heron	5	2		5,000-7,000
Little Egret	19	36		120,000-150,000
Yellow-billed Egret	19	8		<12,000
Great White Egret	22	38		10,000-20,000
Purple Heron	16	9		5,000-10,000
Grey Heron	13	45		8,000-15,000
Goliath Heron	10	23		2,500-4,000
Hamerkop	6	19		100,000-150,000
Yellow-billed Stork	2	198	500	20,000-25,000
Openbill Stork	118	665	1000	20,000-25,000
Woolly-necked Stork	0	1		1,000-4,000
Saddle-billed Stork	3	1		c.6,000
Marabou	6	18		c.15,000
Glossy Ibis	0	87	1000	c.5,000
Hadada	2	5		c.10,000
Sacred Ibis	0	192	2000	c.20,000
African Spoonbill	0	19		8,000-12,000
Fulvous Whistling Duck	0	8		5,000-20,000
White-faced Whistling Duck	17	31		17,500-25,000
Egyptian Goose	182	214	3500	7,000-12,000
Spur-winged Goose	34	4		5,000-15,000
Knob-billed Duck	5	2		2,300-5,000
Fish Eagle	30	34		15,000-20,000
African Marsh Harrier	0	4		2,500-5,000
Grey Crowned Crane	0	2		<5,000
Jacana	78	9		100,000-200,000
Water Thick-knee	155	153	500	
Common Pratincole	74	814	1000	5,000-10,000
Black-winged Stilt	0	5		30,000-40,000
Kittlitz's Sandplover	0	3		10,000-20,000
Three-banded Plover	0	4		
Wattled Plover	103	344	750	
White-crowned Plover	476	324	250	c.8,000
Long-toed Plover	19	4		
Blacksmith Plover	13	76	5000	5,000-10,000
Ruff	1	1		100,000-120,000
Marsh Sandpiper	0	1		7,000-10,000
Greenshank	9	40		5,000-10,000
Common Sandpiper	27	32		>25,000
Grey-headed Gull	0	1		10,000-15,000
African Skimmer	42	376	100	<4,000
Giant Kingfisher	0	5		

Appendix 2: Annotated bird species list

Comments on the most interesting species and observations are given below.

Pelecanidae

White Pelican *Pelecanus onocrotalus*. Very few were found during the waterbird surveys but on 23/7 a large roost of 182 was found (UTM coordinates 02213, 90725) in a group of large *Ficus* trees. This was observed on subsequent nights along with Pink-backed Pelicans, Openbill Storks and White-backed Vultures. A subsequent visit to this site in September found that the roost had been deserted. This may have been caused by the burning of the surrounding tall grass woodland or possibly disturbance by local pastoralists. Pelican colonies are easily deserted (Brown *et al*. 1982), and therefore it is possible that roosts are too. The ease with which these roosts can be counted makes them ideal for assessing sizes of populations which are dispersed during the day. Pelicans tend to leave roosts late and return early because their large size makes soaring flight necessary and this further facilitates counting. It is likely that a number of other roost and possibly nest sites exist in the valley and they should be counted at any opportunity. Recorded previously during January 1995 waterbird count (Baker 1997).

Pink-backed Pelican *Pelecanus rufescens*. Only 49 were seen during the waterbird surveys and only 4 were seen at the roost on 23/7. Some were seen on the rivers at night unlike White Pelican which suggests that they may not roost in trees as regularly. 49 is the largest count so far in the Kilombero.

Phalacrocoracidae

Long-tailed Cormorant *Phalacrocorax africanus*. 64 were recorded during waterbird surveys which is greater than during the 1995 count (Baker 1997).

Ardeidae

Goliath Heron *Ardea goliath*. Baker (1997) suggested that the area may hold important populations of this species. We only found 23 during the waterbird survey which is an increase on the previous count but is still quite low. The patchy nature of the water bodies and the inability of a boat-borne counting team to travel on anything but large channels makes it difficult to comment on this. However, although few were observed outside the systematic surveys, the species is known to local people who catch young birds and raise them for consumption. This suggests that there is likely to be a substantial population but that it could possibly be threatened by over-exploitation as the human population grows.

Black-headed Heron *Ardea melanocephala*. Not strictly a waterside bird and unsurprisingly none were found during waterbird counts. Only one individual, a juvenile, was seen during the whole project, on 6/8 at night on the Furua River. This is surprising considering it is generally associated with grasslands (Britton 1980). It was not recorded during the 1995 survey (Baker 1997) so the lack of records may represent true scarcity in the valley.

Madagascar Squacco Heron *Ardeola idae*. This near-threatened migratory species (Collar *et al*. 1994) is only found on mainland Africa from June to November and will therefore have been missed by the January 1995 survey. Our waterbird survey counted only 17 but this is probably because the survey did not include much suitable habitat. It is present in the valley from June to September (Baker & Baker, in prep.). The valley may possibly hold an important number of this species; more than 100 (Fishpool 1997). Collar and Stuart (1985) suggest that regular monitoring of the non-breeding East African populations of this species are desirable as its breeding population is declining.

Rufous-bellied Heron *Ardeola rufiventris*. Two flocks were seen. The first on 5/9 at Madabadaba (02151, 90581) and the second in Kibasira swamp (90825, 02015) on 8/9. They were feeding in

shallow flooded vegetation on the edge of respectively a shallow stream in the flooded plain and a floating papyrus *Papyrus* swamp. None were seen during the waterbird surveys probably because of its use of seasonally flooded shallow areas and similarly none were seen in 1995 (Baker 1997). Also, its motionless hunting technique will have reduced chances of observations. Expanding its range in Africa so it may be interesting to follow any population changes within the valley.

Cattle Egret *Bubulcus ibis*. A count of 665 was made including 450 at a single flooded grazed area (02044, 90416). Although this species does inhabit wetlands, it is very closely associated with the huge numbers of cattle and wild ungulates within the valley. Therefore waterway surveys such as ours would be likely to miss a large proportion of the population. Indeed, counts undertaken during mammal surveys may be more likely to produce accurate estimates.

Black Heron *Egretta ardesiaca*. Flocks of 2 and 16 were observed during the waterbird survey. This species may be found more frequently on shallow pools and flooded areas. Fuggles-Couchman (1984a) found several flocks of 20-40 on the Mnyera River in 1934. Only 5 were observed in 1995 (Baker 1997). This species may have declined but the most suitable habitat for this species, open shallow water, was not targeted in this survey and the depth of the water can change rapidly with receding flood waters.

Little Egret *Egretta garzetta*. Only 36 individuals were counted which is very few for such a numerous and widespread species. There are estimated to be 150,000 in Tanzania (Baker 1997).

Ciconiidae

Openbill Stork *Anastomus lamelligerus*. See Waterbirds section. Counts were made of 665 including 164 from a flooded grazed area (02044, 90416). This in itself is quite large but when taken in conjunction with the counts of three roosts: 609 on 25/7 (see White Pelican) (02213 90725), c.200 on 4/8 on *Borassus* palms by the Kilombero River (02340, 90888) and c.100 on 6/8 on the upper Furua River in a solitary tree near fields (seen during night crocodile survey, some other species also at roost) (01900 90090), indicates that this valley is probably important for the Openbill Stork, e.g. a flock of 95 was seen on 7/8. Undoubtedly some of the birds observed during the waterbird surveys were using these roosts and therefore the counts cannot be added directly to the roost numbers. However, it is very likely that the total number of individuals observed exceeds the 1% biogeographic threshold level of 1,000 (Fishpool 1997).

Saddle-billed Stork *Ephippiorhynchus senegalensis*. Only one individual was seen during the waterbird surveys which is a very poor count. Only three were seen in 1995 (Baker 1997). It was seen in widely scattered locations across the valley, mainly in dry areas away from water. The low density of the population of this large species could have resulted in some individuals being missed but it is likely that the population is low in the Kilombero.

Yellow-billed Stork *Mycteria ibis*. A count of 198 suggest that the valley may hold important numbers; the 1% level is only 500 (Fishpool 1997). However, the 1995 count suggests an estimated population of 20,000 to 25,000 for Tanzania alone and so the actual biogeographic total may be much greater then 50,000 (Baker 1997). Therefore, the 1% level is likely to be increased in future.

Anatidae

Very few ducks or geese were seen other than Egyptian Geese. As the survey took place during the northern summer, migrant palaearctic species would not have been expected to be present. More surprisingly very few resident Afrotropical duck species were seen. No migrant Palaearctic species were recorded in January 1995 (Baker 1997) and these absences are likely to be real. Many resident and migrant species appear to be absent from east of the Eastern Arc mountains (Baker 1997) and this deserves further study.

Egyptian Goose *Alopochen aegyptiacus*. Common on waterbird survey (214 counted) and also found in other habitats scoring 1.2 (short grass) and 0.8 (wooded short grass) in TSCs. A pair was seen with young (1 week old) goslings on 4/8 (02639, 90977).

Accipitridae

Large numbers of raptors were seen, often at very high density. Especially common were vultures which may, like the abundance of Lions *Panthera leo*, be related to the absence of the predator and scavenger Spotted Hyaena *Crocuta crocuta* within the central floodplain of the valley, although the latter is found at the edges. Snake eagles *Circaetus* spp and Bateleur were also common which indicates that there may be a high density of reptiles and small mammals in the valley. It is suggested that systematic surveys are carried out to provide an estimate of raptor population sizes. Monitoring vulture populations could in turn provide an indicator of the health of large herbivore populations (Mundy *et al*. 1992). Raptor populations show low breeding success during drought, probably because prey availability is lower (Hustler & Howells 1990). The high number of species and the high densities of populations found in the valley may also be related to the low chance of drought in the Kilombero Valley but the high density of prey is probably more important.

African White-backed Vulture *Gyps africanus*. Very common throughout the valley. Many seen roosting in trees early in the morning (especially in *Borassus* palms) and seen in large Pelican *Pelecanus* roost. Frequently seen soaring during the day throughout the valley. Also many were seen at poached hippo carcasses as well as at fish traps (baited with hippo flesh) with Marabou and Hooded Vultures. It is possible that there is a seasonal influx as Buffalo, Elephant and other large mammals migrate into the Kilombero from the Selous G.R. Surveys of this species would be useful in showing the importance of the Kilombero for this species within the Selous ecosystem.

Lappet-faced Vulture *Torgos tracheliotus*. Only one individual of this large, scarce species was seen on 16/7 (02094, 90745). Presumably the breeding area of this species is in the Selous G.R. although there are no breeding records of this species from southern Tanzania (Mundy *et al.* 1992) Large numbers of game are needed to support populations of these species and therefore any reduction in the game population could cause the local extinction of this species (Mundy *et al*. 1992).

White-headed Vulture *Trigonoceps occipitalis*. Uncommon species seen quite frequently in July but not in other months. It has previously been recorded in January and October. The area probably supports quite high numbers of this species but possibly on a seasonal basis following the migrating large mammals, although it does kleptoparasitise the numerous Bateleur (Brown *et al*. 1982). This species relies on good populations of game animals and this species could disappear if large mammal numbers decline (Mundy *et al*. 1992).

Montagu's Harrier *Circus pygargus*. The first record of this species in the Kilombero Valley was of an adult male on 2/9 (02044, 90416). An early record for this palaearctic migrant, most records in East Africa are from October to April (Britton 1980).

African Marsh Harrier *Circus ranivorus*. Relatively common species seen quite frequently, timed species count (TSC) scores of 2 (swamp) and 0.6 (long grass) out of a maximum of 6. This species may be affected by the conversion of grassland into agricultural land but as prey such as rodent and bird crop pests are quite common, habitat loss may not be a major threat to the African Marsh Harrier population in the valley.

Harrier Hawk *Polyboroides radiatus*. Seen in July and August. On the second occasion on 24/8 raiding a nest of Brown-necked Parrots near Itete village (90402, 02160).

Brown Snake Eagle *Circaetus cinereus* Not seen as frequently as Black-chested Snake Eagle but as an inhabitant of more wooded country (Brown *et al*. 1982) it was interesting to see it quite commonly

over short grass and swamp areas. Estimates from Tsavo East NP and Embu suggest that each pair needs 200 sq km of suitable habitat (Britton 1980).

Black-chested Snake Eagle *Circaetus pectoralis*. This species scored 2 (swamp) and 0.6 (long grass) in TSCs and was seen commonly from Kivukoni ferry (02460, 90950) and during waterbird surveys from the boat. Past surveys have shown that a pair needs several hundred square kilometres for its breeding territory (Brown *et al*. 1982) but the high TSC scores indicate that they may be found at a higher density in the valley.

Bateleur *Terathopicus ecaudatus*. Common in open areas, TSC scores of 1.6 (long grass) and 1 (swamp). Probably the most abundant large bird of prey in the valley and possibly a higher density than previously recorded elsewhere (Brown *et al*. 1982).

Ayres' Hawk Eagle *Hieraaetus dubius*. Seen once in an area of wooded short grassland surrounded by burnt grass and swamp. The 'landing lights' at the base of the leading edge of the wings were clearly seen as were the barred tail and flecked/barred undersides of the wings. This is the first record for the Kilombero Valley of this localised and rare species.

Lizard Buzzard *Kaupifalco monogrammicus*. A pair were seen calling by the road east of Ifakara on 16/8 and there were two other sightings on the south side of the valley in September.

Martial Eagle *Polemaetus bellicosus* Seen on a number of occasions in July and August including an immature bird on 14/8 at Madabadaba (02151, 90581). This species is declining in East Africa and becomes rare in settled country (Britton 1980). Its habitat of open woodland is susceptible to clearing by over-grazing, cultivation and fuel-wood collection and therefore it is likely to become scarcer within the valley.

Crowned Eagle *Stephanoaetus coronatus*. One adult seen on 30/8 above miombo woodland on the peak of a steep 700 metre hill (02203, 90337) near Itete village. Will undoubtedly decline in numbers as its habitat, including gallery forest is cleared.

African Fish Eagle *Haliaeetus vocifer*. See Waterbirds section. Thirty-four counted during the waterbird surveys which is similar to the count made in 1995 (Baker 1997). This species spends 85-95% of daylight hours perched near water and much of this time is spent scanning the water (Brown *et al*. 1982). The absence of trees in the valley which are needed for roosting and look out perches may limit the numbers of Fish Eagles within the valley. Firewood is brought in, in large quantities to the centre of the valley by fisherman for cooking and to smoke fish. The wood has to travel some distance to reach the fishing camps and therefore the demand for wood has left very few large trees standing within the valley.

Black Kite *Milvus migrans* Commonly seen, although never in great numbers. One individual carrying a stick on 13/7 and a pair seen mating on 29/7 in the grounds of Ifakara Parish Guest House.

Bat Hawk *Macheiramphus alcinus*. One seen on 13/7 in the grounds of Ifakara Parish Guest House at dusk.

Falconidae

Red-necked Falcon *Falco chicquera*. This species was seen quite frequently in open woodland and over grassland, possibly slightly more common than Dickinson's Kestrel. In TSC surveys scored 2 (swamp) and 0.2 (short grassland). Adult seen feeding grown young in *Borassus* palm on 1/9 (02040, 90357), it must therefore have laid the eggs in July. This species breeds during the dry season in Zambia (Osborne 1981). This uncommon, localised species relies on open country with palms *Borassus* and *Hyphaene* (Britton 1980, Osborne 1981, Brown *et al.* 1982) and their range has apparently been extended in Zambia by planting of *Borassus* and clearance of woodland (Osborne

1981). As there appears to be a good population of this species here, it would be worthwhile to attempt a survey of this species (along with other raptors) to make an estimate or index of its numbers.

Dickinson's Kestrel *Falco dickinsoni*. Seen quite frequently in open woodland. Britton (1980) says that it is locally common in this habitat and often in association with *Borassus* palms. Fuggles-Couchman (1984a) mentions that it was seen in miombo *Brachystegia* woodland near Mikumi in 1951. Largely restricted to the Brachystegia biome (Fishpool 1997).

Phasianidae

Red-necked Spurfowl *Francolinus afer*. Seen commonly, scoring 2.5 (wooded short grass), 1.8 (long grass) and 0.7 (short grass) during TSCs. One young seen with an adult on 4/9 at Madabadaba (02151, 90581).

Gruidae

Grey Crowned Crane *Balearica regulorum*. This species was seen on two occasions: 2 on 2/8 flying west over the Mnyera River and on 7/8 two flocks were seen numbering 37 (01851, 90255) and 28 (01856, 90256) feeding on heavily grazed grass. These are the first records for the valley and represent a range extension of 180 km south-west of the nearest record (west of Iringa) and is almost the most southerly record for Tanzania (Baker 1997). They are probably the first lowland records for Tanzania and the first east of the Eastern Arc mountains other than escaped birds found near Dar-es-Salaam. One record from near Nachingevea, Lindi region could possibly be of a wild bird but it is a very long way from the nearest population (Katondo 1996). Only the populations in coastal Mozambique and South Africa are found below this altitude (Meine & Armstrong 1996, Allan 1997).

Rallidae

Amazingly, not a single species of this family was seen during this study. Previous surveys have recorded Common Moorhen and Black Crake which, considering the extent of wetlands within the valley, is very poor representation.

Heliornithidae

African Finfoot *Podica senegalensis*. Observed on 3/8 on the river below Itete village and on 7/8 on the Furua River (01810, 90218). The smaller wooded streams and rivers were not systematically studied during the waterbird survey and future work could include this to provide estimates of populations of Finfoots and African Black Ducks *Anas sparsa*.

Charadriidae

White-crowned Plover *Vanellus albiceps*. See Waterbirds section. 324 were recorded during the waterbird survey which is above the 1% threshold level of 250 and confirms the area as important for this species (Fishpool 1997). 476 were recorded during the 1995 survey from 140 km of river and the presence of these numbers at different times of the year indicates that this population is probably resident (Baker 1997). Baker (1997) extrapolates this data and suggests that there may be a further 1360 White-crowned Plovers on 400 km of suitable habitat upstream from that survey. However, many of the channels upstream are narrow and very steep as a number of rivers have merged and would therefore be less suitable. Compensating for this, however, our TSCs in long grass areas found that one of the commonest birds was the White-crowned Plover, scoring 3.3 (Figure 2.7, Appendix 3). Therefore this species could indeed be found in very large numbers, perhaps exceeding the numbers suggested by Baker.

Senegal Plover *Vanellus lugubris*. Not a waterside bird and therefore unsurprisingly not recorded during the waterbird survey. Typical of short-grazed or burnt grassland scoring 1.1 (short grass) and 0.7 (wooded short grass) in TSCs.

Wattled Plover *Vanellus senegallus*. A common bird, 344 were counted during the waterbird surveys despite not being a waterside specialist. During TSCs it scored 4.7 in short grass (the most common species), 1.8 (wooded short grass) and 0.9 (long grass) (Figure 2.7, Appendix 3). This gives an indication of its abundance in some habitats. Britton (1980) states that it is a seasonal visitor to the Kilombero River. Although no evidence of breeding was found, it is probable that as it is found in such large numbers and as 103 were found in January 1995 (Baker 1997) it is resident and not a migrant from highland areas. This species will probably be shown to be found in important numbers within the valley as it is the most common short grassland bird (the 1% population threshold is only 750) (Fishpool 1997).

Spur-winged Plover *Vanellus spinosus*. One was seen on 13/9 on a sandbank at Kivukoni ferry. This is the second most southerly record for this species in Tanzania (Baker 1994) although it has also been seen once each in Zambia, Malawi and Botswana (Sinclair *et al.* 1997, Hockey 1997). The Kilombero sighting is part of a possible range expansion since the 1960s which includes two Tanzanian records of breeding in 1991 and 1992 (Baker 1994) as well as 24 in the northern Selous G.R. in 1995 (Baker 1997).

Burhinidae

Spotted Thicknee *Burhinus capensis*. Two groups of three individuals were seen in open woodland at Madabadaba (02151, 90581) on 7/8. The first records of this bird in the valley.

Water Thicknee *Burhinus vermiculatus*. See Waterbirds section. 153 were counted during the waterbird surveys which is a fairly large number. This is very similar to the 155 counted during the 1995 survey (Baker 1997) and suggests that the population may be resident throughout the year although the areas covered by the two surveys do not correspond entirely. Fuggles-Couchman (1984a) states that this species was well distributed along the Kilombero from Ifakara (presumably the ferry) to Malinyi, although he gives no numbers or dates.

Glareolidae

Common Pratincole *Glareola pratincola*. 814 were counted during the waterbird surveys which is close to the 1% level of 1,000 for resident for Afrotropical birds (Fishpool 1997). This count included unusually large flocks of 450 and 285 in which there were many immature birds. Scores of 1.1 (short grass) and 0.6 (long grass) indicate that this species is widespread throughout the valley and it would be surprising if this species, which probably also breeds in the valley, does not number over 1,000. It is known to breed in both wet and dry seasons (Urban *et al*. 1986).

Rynchopidae

African Skimmer *Rynchops flavirostris*. See Waterbirds section. The count of 376 was well above the 1% threshold level of 100 and above the previous count here of 42 in 1995 (Baker 1997). The latter count was in January, outside the breeding season. Seen breeding on 4/8 (02387, 90934), 5/8 (02084, 90684) and 7/8 (02037, 90702). The Kilombero Valley is obviously of great importance for this declining species and has been so for some time (Baker 1997). Fuggles-Couchman (1984a) found them to be common west of Ifakara ferry in 1932 and again between 1952 and 1953. He also found two chicks in August 1953. Britton (1980) states that the birds breed in the Kilombero during July.

Psittacidae

Brown-headed Parrot *Poicephalus cryptoxanthus*. Largely restricted to the East African Coast biome. A nest hole 30 metres high in a hole in a dead tree near Itete village (02203, 90337) was seen being raided by a Harrier Hawk on 24/8.

Cuculidae

Levaillant's Cuckoo *Clamator levaillantii*. One was seen on the bank of the main Kilombero River flying into reeds on 16/7 (02100, 90755). Britton (1980) states that it is only common in south-east Tanzania from November to April.

Coppery-tailed Coucal *Centropus cupreicaudus*. Common bird in long grass and reeds in the interior of the valley, being heard more frequently than it was seen. This is an unusual lowland population of this species (Britton 1980, Baker 1990). Largely restricted to the *Brachystegia* biome.

Black Coucal *Centropus grillii*. One bird was heard calling on 11/9 (02057, 90900). This was at gallery forest/tall grassland edge on the Ruipa River which was in the process of being cleared for crops. Fuggles-Couchman (1984a) has a record of the species near Ifakara during flooding in May 1957.

White-browed Coucal *Centropus superciliosus*. The nominate race was common in open habitats with some cover: TSC scores of 1.7 (long grass), 1 (swamp) and 0.7 (wooded short grass). Britton (1980) states that the subspecies *burchelli*, a distinctive race, now thought to be a separate species is found along the Kilombero River. *Burchelli*, normally found along the coast, was not observed during this study but it is very similar to the Senegal Coucal and quite similar to the Coppery-tailed Coucal so it may have been missed by us. Future surveys making greater use of recording equipment would be useful to reduce confusion. Senegal Coucal is normally almost entirely allopatric from both White-browed and Burchell's Coucal (Britton 1980). The presence of five species *Centropus* in the valley is noteworthy and deserves further investigation.

Tytonidae

Barn Owl *Tyto alba*. One was heard calling on 6/9 on the edge of Ifakara at midnight.

Strigidae

Spotted Eagle Owl *Bubo africanus*. One seen during a TSC on 1/9 at 10:15 am in woodland adjoining tall grassland (02022, 90370).

African Wood Owl *Strix woodfordii*. Heard calling at 11 pm in *Brachystegia* woodland near Itete village on 30/7.

Barred Owlet *Glaucidium capense*. One seen on 21/8 in tall woodland edge close to the Selous G.R. (02515, 90927).

White-faced Scops Owl *Otus leucotis*. Heard twice, the first occasion at the same time as the African Wood Owl near Itete village on 30/7 and the second occasion at the same location on 10/8. These are the first records for this uncommon species in the Kilombero Valley.

Pel's Fishing Owl *Scotopelia peli*. One individual was seen (unfortunately not by HJR) on 7/8 on the Furua River (01810, 90218) during a night-time crocodile survey. This scarce species has been recorded at a number of locations across the valley. However, it requires tree-lined rivers (Britton 1980) and this habitat is disappearing rapidly.

Caprimulgidae

Square-tailed Nightjar *Caprimulgus fossii*. Common throughout the valley in most open habitats scoring 1.5 (wooded short grass) and 0.6 (long grass) in TSCs. Two males were netted and they were frequently disturbed during mammal transects. Surprisingly only this species was recorded although two other species have been recorded in the Kilombero Valley in the past. There is a small possibility that this species was misidentified but it was generally seen at very close range when the single white outer tail feathers are clearly visible.

Apodidae

Little Swift *Apus affinis*. This species was seen around human habitation near Malinyi village on the south-east side of the valley on 1/8. Common in Ifakara, many seen on 19/8 and appeared to be carrying food to nests on the mission building in Mofu on 19/8 and 8/9. A very localised distribution, only found in the vicinity of tall buildings.

African Black Swift *Apus barbatus*. A number of large dark swifts were seen flying over the lower Kilombero River near where it enters the Selous G.R. on 22/8 (02555, 90964). Reasonable views were had and the inner secondaries appeared to be paler than the rest of the wing. Other swifts of similar appearance would be unlikely to be present in the valley at this time and none were seen during field work from mid-July until mid-September. Common Swift *Apus apus* not usually being present until December (Britton 1980) although there is a previous record for this species in August in the valley. Nyanza Swift *Apus niansae* is not found in the area. Mottled Swift *Tachymarptis aequatorialis* could be found feeding in the area but it is much larger and has a more powerful flight.

Mottled Spinetail *Telacanthura ussheri*. A group of 4 was seen circling over tall grass within moist woodland on 5/9 (02148, 90568). In West Africa it is found in similar *Borassus* palm savanna (Chantler & Driessens 1995).

Alcedinidae

Giant Kingfisher *Megaceryle maxima*. Recorded on five occasions along the valley from the south-west on the Mnyera river to the north-east where the Kilombero River enters the Selous G.R. All records were from medium to large rivers with well-wooded banks, a habitat that is becoming increasingly scarce as, especially in the west and south-west gallery forest is being cleared for fields. Britton (1980) records it as an uncommon resident along waterbodies with well-timbered banks. Fuggles-Couchman (1984a) records it from the Sanje River, Ulanga district in March 1933. The south-eastern side of the Kilombero Valley is in Ulanga district.

Meropidae

Boehm's Bee-eater *Merops boehmi*. One seen on 8/9 in woodland on the edge of Kibasira swamp. This uncommon species relied on wooded areas near water and will be vulnerable to clearance of forest for fields along rivers (Britton 1980). Largely restricted to the Brachystegia biome (Fishpool 1997).

White-fronted Bee-eater *Merops bullockoides*. Very frequently seen during the waterbird surveys along the cliffs and banks of the rivers. Not common away from the rivers; it was not seen during the TSCs. Seen entering holes in a river bank on 4/8 (02387, 90934) and on 22/8 (02533, 90971).

Bucerotidae

Silvery-cheeked Hornbill *Bycanistes brevis*. Seen quite frequently in wooded areas of the valley. Regarded as allopatric with Trumpeter Hornbill by Britton (1980) but not by Snow (1979) or Kemp (1995). Silvery-cheeked Hornbill seen on 10/9 and Trumpeter Hornbill on 11/9 on the Ruipa River (02030, 90928).

Trumpeter Hornbill *Bycanistes bucinator*. Seen only on the north-west side of the valley in wooded areas. See Silvery-cheeked Hornbill.

Crowned Hornbill *Tockus alboterminatus*. The dark race *suahelicus* was reasonably common in wooded areas.

Capitonidae

Black-collared Barbet *Lybius torquatus*. Seen occasionally in woodland in July and September. There are two old records from Ulanga district. Fuggles-Couchman (1984b) saw one in Kiberege in March 1933 and Williams (1966) described a new subspecies from Ulanga district although at 600 metres and therefore on the Mahenge escarpment.

Yellow-fronted Tinkerbird *Pogoniulus chrysoconus*. Seen twice, the second observation of a bird occupying a hole in a tree in our camp site near Itete village from 13/9 onwards and believed to be nesting.

Picidae

Only three small species were recorded during this survey. The Golden-tailed Woodpecker has been recorded once before (Baker & Baker, in prep.).

Stierling's Woodpecker *Dendropicos stierlingi*. Observed on 24/8 in grazed open woodland near Itete. This near-threatened species is largely restricted to the Brachystegia biome (Collar *et al.* 1994, Fishpool 1997). It is very poorly known and would benefit from systematic bird surveys in woodland surrounding the valley. Previously recorded from the north-west side of the valley (Baker & Baker, in prep.). The distribution of this species extends into Mozambique and follows Lake Malawi around into Malawi. As such, this species is probably found at its lowest altitude in the Kilombero valley. Possibly the rarest African woodpecker and because of the large area of sparsely populated woodland around the valley and in the Selous, this ecosystem must be important for this species.

Hirundinidae

Grey-rumped Swallow *Pseudhirundo griseopyga*. Found quite commonly over short or burnt grassland. TSC scores of 2 (wooded short grass), 1 (long grass) and 0.1 (short grass). The low TSC score for short grass could be related to the susceptibly to flooding of these areas where these surveys were carried out. However, many were seen flying around the very short over-grazed grassland around Kivukoni on 20/8 and appeared to be investigating holes in the ground. On 13/8 at Madabadaba (02121, 90557) birds were seen entering holes in the earth in burnt grassland within open woodland. They appeared to be carrying prey and were assumed to be breeding. Fuggles-Couchman (1984a) saw up to 200 on 6 November 1932, at this time they would not be breeding because the rains would have started. It implies that this highland species, normally found at 900-2200 metres in East Africa (Britton 1980) is resident here.

Lesser Striped Swallow *Hirundo abyssinica*. Appeared to be entering nests on the mission building in Mofu village on 8/9.

Wire-tailed Swallow *Hirundo smithii*. Common throughout the valley scoring 1.4 (long grass), 1.4 (short grass) and 1(wooded short grass) in TSCs. Seen entering nest with food on 17/7 (02115, 90780) and in late July seen adding mud to nest cup on ferry boat at Kivukoni. Seen collecting mud from river bank on 4/8 (02629, 90977).

Black Saw-wing *Psalidoprocne pristoptera*. The subspecies *orientalis* was common over *Brachystegia* woodland.

African Sand Martin *Riparia paludicola*. Seen entering nest holes in river bank on 22/8 (02697, 90982). Seen throughout the year and therefore probably resident (Baker & Baker, in prep.).

Pycnonotidae

A number of species were seen and netted but unfortunately good views were not always obtained and poor photograph quality has not enabled identification of all species that were trapped.

Turdidae

Capped Wheatear *Oenanthe pileata*. Common in areas with short or burnt grass, scoring 1.8 in TSCs. Amazingly, considering its abundance and the availability of suitable habitat, this widespread species (Britton 1980) has not been recorded before in the Kilombero valley.

Stonechat *Saxicola torquata*. Reasonably common in long grass areas scoring 1.2 in TSCs. Observations from this study and from Baker & Baker (in prep.) in the Kilombero Valley are the lowest altitude records for this species in East Africa.

Orange Ground Thrush *Zoothera gurneyi*. One individual was seen drinking in riverine forest at the edge of the floodplain on 26/7 (90620, 02275), typical habitat for this species (Urban *et al*. 1997). This is a low altitude record for a species normally found in highland forest (Britton 1980). There are previous records for this species at this altitude in Matundu F.R. in September (Baker & Baker, in prep.) and Magombera and Mwanihana forests (Stuart *et al*. 1987). These records probably represent altitudinal migration from the Udzungwa Mountains or Mahenge Highlands during the colder dry season.

Sylviidae

Rattling Cisticola *Cisticola chiniana*. Seen feeding young and also heard calling on a number of occasions in July and August.

Cisticola No.1 *Cisticola sp.* See Cisticola section. One of two, as yet, undescribed species (Baker & Baker 1990). Frequently heard calling in certain habitats and therefore likely to be breeding from at least July to September. A number of recordings were made of the call of this incipient species which it is hoped will aid its description. Some English names for these new species have been suggested by tour guides who have posted the records of their brief visits to the valley on the internet. It is my opinion that neither of these should be used, at least until these Cisticolas are described, as neither name is entirely appropriate.

Cisticola No.2 *Cisticola sp.* See Cisticola section. One of two, as yet, undescribed species (Baker & Baker 1990). Commonly seen in certain habitats, more so than the previous species although this may be because of its more conspicuous habits. Not heard calling and therefore presumed not to breed at this time of year.

Platysteiridae

East Coast Batis *Batis soror*. Seen quite frequently in open woodland, in thicker habitat than the Black-headed Batis. Largely restricted to the East Coast biome. These two species are commonly sympatric.

Monarchidae

Livingstone's Flycatcher *Eythrocercus livingstonei*. A feeding party of 3 was seen during a TSC in moist open woodland with tall grass (02154, 90577). They were seen gleaning leaves and moving

quickly between branches at a height of 1.5-3 metres. This is a range extension of 120 km west of the Luwegu River (Britton 1980) and 200 km north of Peramiho (Fuggles-Couchman 1984b).

Paridae

Rufous-bellied Tit *Parus rufiventris*. Largely restricted to the Brachystegia biome.

Nectarinidae

Uluguru Violet-backed Sunbird *Anthreptes neglectus*. Seen in *Brachystegia* woodland near Itete village on 25/8, 13/9 and 15/9. Largely restricted to the East Coast biome. Previously regarded as near-threatened (Collar & Stuart 1985) but since regarded as under less threat (Collar et al. 1994).

Oriolidae

African Golden Oriole *Oriolus auratus*. Seen commonly in *Brachystegia* woodland around Itete. A male seen chasing a Black-headed Oriole near Itete village on 27/7.

Sturnidae

Yellow-billed Oxpecker *Buphagus africanus*. Frequently seen in association with Buffalo *Syncerus caffer* and often the only warning of the presence of a herd when walking in long grass. This declining species is only found in areas with game and un-dipped livestock (Britton 1980). As such it is a good indicator of the health of the Kilombero game populations. The Red-billed Oxpecker has been seen in the past but must be less common as it was not seen during our survey when the majority of migratory large herbivores are present in the valley.

Ploceidae

Fan-tailed Widowbird *Euplectes axillaris*. Probably the most common bird in the valley scoring 5 (long grass), 3.75 (swamp), 2.8 (wooded short grass) and 2.2 (short grass) in TSCs (Figure 2.9, Appendix 3). No males seen in breeding plumage. A common pest of crops which can devastate rice (Allan 1996). Apparently a considerable pest in the valley according to comments from our game guards, guides and some local people.

Southern Red Bishop *Euplectes orix*. One male seen on the upper Mnyera River on 1/8. This species is normally found between 600 and 1500 metres (Britton 1980).

Dark-backed Weaver *Ploceus bicolor*. An individual of the black-backed race was seen once on 30/8 in low gallery forest near Itete village. The Kilombero Valley is apparently at the meeting point of three races: brown to the east; grey to the west; and black recorded here and to the north (Hall & Moreau 1970).

Kilombero Weaver *Ploceus burnieri*. See Kilombero Weaver section. Common near water away from areas with trees and bushes. Most easily seen at Kivukoni ferry feeding on refuse from the shops. No breeding activity seen and not seen in breeding plumage. Almost totally separated by habitat from the Golden Weaver *P. subaureus*. *P. burnieri* is benefiting from gallery forest and woodland clearance as *P. subaureus* is probably more competitive in these natural habitats, and *P. burnieri* appears to feed successfully on human waste and other artificial food sources such as smoked fish on drying racks. Possibly out-competing the Grey-headed Sparrow in artificial waterside habitats as the latter species is more likely to be found in more urban situations. Perhaps one of the few globally threatened species to benefit from man's activities.

Golden Weaver *Ploceus subaureus*. Not found in the central floodplain in treeless areas and could be less competitive there than the Kilombero Weaver *P. burnieri*. Seen in a number of locations

surrounding the valley including Boma Ulanga, Mnyera River (breeding 1/8), Ifakara (breeding 30/7) and Mofu. This supports Baker & Baker's (1990) view that *P. burnieri* has a very restricted distribution and is endemic to the floodplain of the valley. It also indicates that identification of both species was accurate during this study as *P. subaureus* was in breeding plumage and *P. burnieri* was not. This species will undoubtedly suffer from the cutting of gallery forest within the valley although it appeared to be breeding successfully in human habitats in Ifakara and along the Mnyera River. See separate section on the Kilombero Weaver.

Red-headed Quelea *Quelea erythrops*. Very common, scoring 5.25 (swamp), 2.8 (long grass) and 2.8 (short grass) in TSCs (Figure 2.9, Appendix 3). A common pest of crops, in some areas of Africa it is considered a major deterrent to rice cultivation (Allan 1996). As rice cultivation increases and as the area of the valley used for sugar cane cultivation expands this species will probably increase in numbers, especially as sugar cane provides important roosts for this species (Allan 1996).

Red-billed Quelea *Quelea quelea*. Few seen compared to the Red-headed Quelea. Movements tend to fluctuate seasonally and breeding is linked to rainfall (Britton 1980). As this survey took place during the dry season, it is not surprising that it was seen infrequently.

Grey-headed Sparrow *Passer griseus* Surprisingly scarce in the valley although because of its association with artificial habitats it may have been overlooked. Seen in Itete village on 15/8. It was not identified beyond being a member of the *griseus* superspecies although both *P. griseus* and Swahili Sparrow *P. suahelicus* have been seen in the valley before (Hall & Moreau 1970, Baker & Baker, in prep.).

House Sparrow *Passer domesticus*. The first record for the valley, in Ifakara Hospital grounds on 30/7. Seen there on subsequent visits in August and September.

Broad-tailed Paradise Whydah *Vidua obtusa*. The first record for the valley. It parasitises the Orange-winged Pytilia. Identified by observations of males in breeding plumage and may possibly breed at this time of year in the valley. Largely restricted to the Brachystegia biome.

Estrildidae

Orange-winged Pytilia *Pytilia afra*. One record on 21/8 (near 02515, 90927). Regarded as scarce and inexplicably local by Britton (1980). Parasitised by Broad-tailed Paradise Whydah.

Emberizidae

Cinnamon-breasted Rock Bunting *Emberiza tahapisi*. Seen occasionally in *Brachystegia* woodland. Generally recorded above 400 metres in East Africa (Britton 1980).

Appendix 3: Timed Species Count Scores

Timed species counts for each species in each habitat within which it was recorded. The number of counts made is given by 'n'.
Habitats: WSG – wooded short grass; SW – swamp; LG – long grass; SG – short grass.

Species		**Habitat**			
		WSG n=6	**SW** n=4	**LG** n=10	**SG** n=7
Pink-backed Pelican	*Pelecanus rufescens*			0.6	
Long-tailed Cormorant	*Phalacrocorax africanus*		1.0		
Goliath Heron	*Ardea goliath*		1.25		
Purple Heron	*Ardea purpurea*			0.2	
Squacco Heron	*Ardeola ralloides*	0.5	1.5	0.1	1.1
Cattle Egret	*Bubulcus ibis*	0.5	4.0	1.9	2.0
Green-backed Heron	*Butorides striatus*		1.5		
Great White Egret	*Egretta alba*		0.25		
Black Heron	*Egretta ardesiaca*		1.5		
Night Heron	*Nycticorax nycticorax*		0.5		
Hamerkop	*Scopus umbretta*	0.8	2.25	0.3	0.4
Open-billed Stork	*Anastomus lamelligerus*		1.5		
Marabou	*Leptoptilos crumeniferus*	0.8		0.5	1.1
Yellow-billed Stork	*Mycteria ibis*				0.8
Hadada Ibis	*Bostrychia hagedash*		1.25		
Glossy Ibis	*Plegadis falcinellus*		1.25		
Egyptian Goose	*Alopochen aegyptiacus*	0.8		1.1	1.2
White-backed Vulture	*Gyps africanus*	0.3	1.0	1.1	1.5
Hooded Vulture	*Neophron monachus*			0.3	
Montagu's Harrier	*Circus pygargus*		1.25		
African Marsh Harrier	*Circus ranivorus*		2.0	0.6	
Brown Snake Eagle	*Circaetus cinereus*		0.75		0.2
Black-chested Snake Eagle	*Circaetus gallicus*		2.0	0.6	
Bateleur	*Terathopicus ecaudatus*		1.0	1.6	0.5
Ayres' Hawk Eagle	*Hieraaetus dubius*	0.5			
Lizard Buzzard	*Kaupifalco monogrammicus*			0.1	
Long-crested Eagle	*Lophaetus occiptalis*	0.2			
African Fish Eagle	*Haliaeetus vocifer*		0.5	0.8	1.7
Black Kite	*Milvus migrans*			0.6	0.2
Black-shouldered Kite	*Elanus caeruleus*		1.5	0.2	0.8
Red-necked Falcon	*Falco chicquera*		1.5		0.2
Red-necked Spurfowl	*Francolinus afer*	2.5		1.8	0.7
Black-bellied Bustard	*Eupodotis melanogaster*				0.8
White-headed Plover	*Vanellus albiceps*	0.5	1.25	3.3	0.8
Blacksmith Plover	*Vanellus armatus*	0.5		0.2	0.1

Long-toed Plover	*Vanellus crassirostris*	0.5	1.5		
Senegal Plover	*Vanellus lugubris*	0.7	1.25	0.3	1.1
Wattled Plover	*Vanellus senegallus*	1.8	3.0	0.9	4.7
Spotted Redshank	*Tringa erythropus*			0.6	
Wood Sandpiper	*Tringa glareola*				0.2
Water Thickknee	*Burhinus vermiculatus*		1.0	0.1	
Temminck's Courser	*Cursorius temminckii*				0.5
Violet-tipped Courser	*Rhinoptilus chalcopterus*				
Common Pratincole	*Glareola pratincola*			0.6	1.1
Ring-necked Dove	*Streptopelia capicola*	4.8	5.0	1.6	4.0
Red-eyed Dove	*Streptopelia semitorquata*	2.0	4.5	0.8	2.2
Blue-spotted Wood Dove	*Turtur afer*	1.0			0.8
Emerald-spotted Wood Dove	*Turtur chalcospilos*	1.3		0.5	
Green Pigeon	*Treron calva*	1.7			
Go-away Bird	*Corythaixoides concolor*			0.6	0.8
Coppery-tailed Coucal	*Centropus cupreicaudus*		1.5		
Senegal Coucal	*Centropus senegalensis*	0.3			
White-browed Coucal	*Centropus superciliosus*	0.7	1.0	1.7	0.1
Spotted Eagle Owl	*Bubo africanus*			0.6	
Gabon Nightjar	*Caprimulgus fossii*	1.5	0.25	0.6	
Palm Swift	*Cypsiurus parvus*	1.3	2.75		1.8
Speckled Mousebird	*Colius striatus*		0.25		
Pied Kingfisher	*Ceryle rudis*	0.5	1.0	0.1	0.5
Striped Kingfisher	*Halcyon chelcuti*		0.5		0.8
Pygmy Kingfisher	*Ispidina picta*	0.7			
Little Bee-eater	*Merops pusillus*	1.0	1.25	1.0	2.7
Madagascar Bee-eater	*Merops superciliosus*			1.3	
Lilac-breasted Roller	*Coracias caudata*	2.8	3.0		2.5
Hoopoe	*Upupa epops*	0.2			
Grey Hornbill	*Tockus nasutus*	0.3			
Southern Ground Hornbill	*Bucorvus cafer*	0.3			0.5
Lesser Honeyguide	*Indicator minor*	0.5			
Stierling's Woodpecker	*Dendropicos stierlingi*	0.2			
Flappet Lark	*Mirafra rufocinnamomea*	1.8		1.2	1.4
Grey-rumped Swallow	*Pseudhirundo griseopyga*	2.0		1.0	0.1
Wire-tailed Swallow	*Hirundo smithii*	1.0		1.4	1.4
African Pipit	*Anthus cinnamomeus*	0.5		2.2	0.7
Zanzibar Sombre Greenbul	*Andropadus importunus*	0.5			
Common Bulbul	*Pycnonotus barbatus*	5.0	3.75	0.3	1.0
Capped Wheatear	*Oenanthe pileata*			0.3	1.8
Stonechat	*Saxicola torquata*			1.2	0.2
Rattling Cisticola	*Cisticola chiniana*	1.8	0.75		1.0
Cisticola No. 1	*Cisticola sp.*		2.75	2.1	2.4
Cisticola No. 2	*Cisticola sp.*				
Tawny-flanked Prinia	*Prinia subflava*	2.3		0.2	

Moustached Warbler	*Sphenoeacus mentalis*			0.9	
Black-headed Batis	*Batis minor*		1.0		
East Coast Batis	*Batis soror*	0.2			
Black-throated Wattle-eye	*Platysteira peltata*	0.5			
African Paradise Flycatcher	*Terpsiphone viridis*	0.5			
Arrow-marked Babbler	*Turdoides jardineii*	0.7		0.4	
Scarlet-chested Sunbird	*Chalcomitra senegalensis*	0.5			
Variable Sunbird	*Cinnyris venusta*	0.5	3.0	0.3	
Black-backed Puffback	*Dryoscopus cubla*	0.5	0.5		
Tropical Boubou	*Laniarius aethiopicus*	0.3			
Grey-headed Bush Shrike	*Malaconotus blanchoti*	1.0			
Orange-breasted Bush Shrike	*Malaconotus sulfreopectus*	0.8			
Brubru	*Nilaus afer*	1.0			
Black-crowned Tchagra	*Tchagra senegala*	3.3	1.0	0.6	0.7
Fork-tailed Drongo	*Dicrurus adsimilis*	1.5	0.25		
Pied Crow	*Corvus albus*		1.5	0.6	
Yellow-billed Oxpecker	*Buphagus africanus*	0.5		0.4	
Fan-tailed Widowbird	*Euplectes axillaris*	2.8	3.75	5.0	2.2
Kilombero Weaver	*Ploceus burnieri*			0.1	1.0
Village Weaver	*Ploceus cucullatus*	1.0			
Golden Weaver	*Ploceus subaureus*	0.7			
Red-headed Quelea	*Quelea erythrops*		5.25	2.8	2.8
Broad-tailed Paradise Whydah	*Vidua obtusa*			0.3	0.8
Zebra Waxbill	*Amandava subflava*			0.5	0.8
African Firefinch	*Lagonosticta rubricata*	0.5			0.7
Red-billed Firefinch	*Lagonosticta senegala*	1.8		1.2	1.4
Angola Cordonbleu	*Uraeginthus angolensis*	4.8			
Yellow-fronted Canary	*Serinus mozambicus*	1.2		1.9	0.8

Appendix 4: Bird species list for the Kilombero Valley

List of species recorded by the Tanzanian Bird Atlas Project (TABAP) and this study (KVWP).
B – confirmed breeding, b – probable breeding. VU – vulnerable, nt – near-threatened, DD – data deficient.

Family	Species	Scientific name	TABAP	KVWP	Breeding	Notes
Pelecanidae	White Pelican	*Pelecanus onocrotalus*	x	x		
	Pink-backed Pelican	*Pelecanus rufescens*	x	x		
Phalacrocoracidae	Long-tailed Cormorant	*Phalacrocorax africanus*	x	x		
	Greater Cormorant	*Phalacrocorax carbo*	x			
Anhingidae	Darter	*Anhinga rufa*	x	x		
Ardeidae	Little Bittern	*Ixobrychus minutus*	x	x		
	Grey Heron	*Ardea cinerea*	x	x		
	Goliath Heron	*Ardea goliath*	x	x		
	Black-headed Heron	*Ardea melanocephala*	x	x		
	Purple Heron	*Ardea purpurea*	x	x		
	Madagascar Squacco Heron	*Ardeola idae*	x	x		**nt**, Intra-African migrant
	Squacco Heron	*Ardeola ralloides*	x	x		
	Rufous-bellied Heron	*Ardeola rufiventris*	x	x		
	Cattle Egret	*Bubulcus ibis*	x	x		
	Green-backed Heron	*Butorides striatus*	x	x		
	Great White Egret	*Egretta alba*	x	x		
	Black Heron	*Egretta ardesiaca*	x	x		
	Little Egret	*Egretta garzetta*	x	x		
	Yellow-billed Egret	*Egretta intermedia*	x	x		
	White-backed Night Heron	*Gorsachius leuconotus*	x			
	Night Heron	*Nycticorax nycticorax*	x	x		
Scopidae	Hamerkop	*Scopus umbretta*	x	x		

Family	Species	Scientific name	TABAP	KVWP	Breeding	Notes
Ciconiidae	Open-billed Stork	*Anastomus lamelligerus*	x	x		
	Abdim's Stork	*Ciconia abdimii*	x			
	Woolly-necked Stork	*Ciconia episcopus*		x		
	Saddle-billed Stork	*Ephippiorhynchus senegalensis*	x	x		
	Marabou	*Leptoptilos crumeniferus*	x	x		
	Yellow-billed Stork	*Mycteria ibis*	x	x		
Threskiornithidae	Hadada Ibis	*Bostrychia hagedash*	x	x		
	Glossy Ibis	*Plegadis falcinellus*	x	x		
	Sacred Ibis	*Threskiornis aethiopica*	x	x		
	African Spoonbill	*Platalea alba*	x	x		
Anatidae	Fulvous Whistling Duck	*Dendrocygna bicolor*		x		
	White-faced Whistling Duck	*Dendrocygna viduata*	x	x		
	Egyptian Goose	*Alopochen aegyptiacus*	x	x	B	
	Spur-winged Goose	*Plectopterus gambensis*	x	x		
	Knob-billed Duck	*Sarkidiornis melanotos*	x	x		
	White-backed Duck	*Thalassornis leuconotos*	x			
Accipitridae	Palm-nut Vulture	*Gypohierax angolensis*	x	x	b	
	White-backed Vulture	*Gyps africanus*	x	x		
	Hooded Vulture	*Neophron monachus*	x	x		
	Lappet-faced Vulture	*Torgos tracheliotus*	x	x		
	White-headed Vulture	*Trigonoceps occipitalis*	x	x		
	Eurasian Marsh Harrier	*Circus aeruginosus*	x			Eurasian migrant
	Montagu's Harrier	*Circus pygargus*		x		Eurasian migrant
	African Marsh Harrier	*Circus ranivorus*	x	x		
	Harrier Hawk	*Polyboroides radiatus*	x	x	B	
	Brown Snake Eagle	*Circaetus cinereus*	x	x		
	Southern Banded Snake Eagle	*Circaetus cinarescens*	x			**nt**, East African Coast biome
	Black-chested Snake Eagle	*Circaetus pectoralis*	x	x		
	Bateleur	*Terathopicus ecaudatus*	x	x		
	Shikra	*Accipiter badius*	x	x	B	
	Great Sparrowhawk	*Accipiter melanoleucus*		x		

Family	Species	Scientific name	TABAP	KVWP	Breeding	Notes
	Little Sparrowhawk	*Accipiter minullus*	x	x		
	Ovampo Sparrowhawk	*Accipiter ovampensis*	x			
	African Goshawk	*Accipiter tachiro*	x	x	b	
	Tawny Eagle	*Aquila rapax*	x			
	Wahlberg's Eagle	*Aquila wahlbergi*	x	x		
	Common Buzzard	*Buteo buteo*	x			subsp *vulpinus,* Eurasian migrant
	Ayres' Hawk Eagle	*Hieraaetus dubius*		x		
	Lizard Buzzard	*Kaupifalco monogrammicus*	x	x		
	Long-crested Eagle	*Lophaetus occiptalis*	x	x		
	Gabar Goshawk	*Melierax gabar*	x	x		
	Dark Chanting Goshawk	*Melierax metabates*		x		
	Martial Eagle	*Polemaetus bellicosus*	x	x		
	Crowned Eagle	*Stephanoaetus coronatus*	x	x	b	
	African Fish Eagle	*Haliaeetus vocifer*	x	x	b	
	Black Kite	*Milvus migrans*	x	x	B	subsp *parasiticus*
	Black-shouldered Kite	*Elauns caeruleus*	x	x		
	Bat Hawk	*Macheiramphus alcinus*	x	x		
Falconidae	Eastern Red-footed Falcon	*Falco amurensis*	x			Eurasian migrant
	Red-necked Falcon	*Falco chicquera*	x	x	B	
	African Hobby	*Falco cuvierii*	x			
	Dickinson's Kestrel	*Falco dickinsoni*	x	x		Brachystegia biome
	European Hobby	*Falco subbuteo*	x			Eurasian migrant
	Kestrel	*Falco tinnunculus*	x			
	Pygmy Falcon	*Polihierax semitorquatus*	x			
Phasianidae	Harlequin Quail	*Coturnix delegorguei*	x			
	Red-necked Spurfowl	*Francolinus afer*	x	x	B	
	Coqui Francolin	*Francolinus coqui*	x			
	Crested Francolin	*Francolinus sephaena*	x	x		
Numididae	Crested Guineafowl	*Guttera pucherani*	x			
	Helmeted Guineafowl	*Numida meleagris*	x	x		

Family	Species	Scientific name	TABAP	KVWP	Breeding	Notes
Rallidae	Common Moorhen	*Gallinula chloropus*	x			
	Black Crake	*Amaurornis flavirostris*	x			
Gruidae	Crowned Crane	*Balearica pavonina*		x		
Heliornithidae	African Finfoot	*Podica senegalensis*	x	x	b	
Otididae	Black-bellied Bustard	*Eupodotis melanogaster*	x	x		
Jacanidae	African Jacana	*Actophilornis africanus*	x	x		
Charadriidae	Little Ringed Plover	*Charadrius dubius*	x			Eurasian migrant
	Ringed Plover	*Charadrius hiaticula*	x			Eurasian migrant
	White-fronted Sandplover	*Charadrius marginatus*	x		b	
	Kittlitz's Sandplover	*Charadrius pecuarius*		x		
	Three-banded Plover	*Charadrius tricollaris*	x	x		
	White-headed Plover	*Vanellus albiceps*	x	x	B	
	Blacksmith Plover	*Vanellus armatus*	x	x	B	
	Crowned Plover	*Vanellus coronatus*	x			
	Long-toed Plover	*Vanellus crassirostris*	x	x		
	Senegal Plover	*Vanellus lugubris*	x	x		
	Wattled Plover	*Vanellus senegallus*	x	x		
	Spur-winged Plover	*Vanellus spinosus*		x		
Scolopacidae	Common Sandpiper	*Actitis hypoleucos*	x	x		Eurasian migrant
	Spotted Redshank	*Tringa erythropus*		x		Eurasian migrant
	Wood Sandpiper	*Tringa glareola*	x	x		Eurasian migrant
	Greenshank	*Tringa nebularia*	x	x		Eurasian migrant
	Green Sandpiper	*Tringa ochropus*	x			Eurasian migrant
	Marsh Sandpiper	*Tringa stagnatilis*		x		Eurasian migrant
	Curlew Sandpiper	*Calidris ferruginea*	x			Eurasian migrant
	Little Stint	*Calidris minuta*	x			Eurasian migrant
	Temminck's Stint	*Calidris temminckii*	x			Eurasian migrant
	Ruff	*Philomachus pugnax*	x	x		Eurasian migrant

Family	Species	Scientific name	TABAP	KVWP	Breeding	Notes
	Black-winged Stilt	*Himantopus himantopus*	x	x		
Burhinidae	Spotted Thickknee	*Burhinus capensis*		x		
	Water Thickknee	*Burhinus vermiculatus*	x	x		
Glareolidae	Temminck's Courser	*Cursorius temminckii*		x		
	Violet-tipped Courser	*Rhinoptilus chalcopterus*	x			
	Common Pratincole	*Glareola pratincola*	x	x		
Laridae	Heuglin's Gull	*Larus heuglini*	x			Eurasian migrant
	Grey-headed Gull	*Larus cirrocephalus*		x		
	White-winged Black Tern	*Chlidonias leucopterus*	x			
	Gull-billed Tern	*Gelochelidon nilotica*	x			Eurasian migrant
Rynchopidae	African Skimmer	*Rynchops flavirostris*	x	x	B	
Columbidae	Lemon Dove	*Aplopelia larvata*	x			
	Olive Pigeon	*Columba arquatrix*	x			
	Namaqua Dove	*Oena capensis*	x			
	Ring-necked Dove	*Streptopelia capicola*	x	x	B	
	Mourning Dove	*Streptopelia decipiens*	x			
	Red-eyed Dove	*Streptopelia semitorquata*	x	x	B	
	Blue-spotted Wood Dove	*Turtur afer*	x	x	b	
	Emerald-spotted Wood Dove	*Turtur chalcospilos*	x	x		
	Tambourine Dove	*Turtur tympanistria*	x		b	
	Green Pigeon	*Treron calva*	x	x		
Psittacidae	Brown-headed Parrot	*Poicephalus cryptoxanthus*	x	x	B	East African Coast biome
	Brown Parrot	*Poicephalus meyeri*	x			
Musophagidae	Go-away Bird	*Corythaixoides concolor*	x	x		
	Livingstone's Turaco	*Tauraco livingstonii*	x	x		
	Violet-crested Turaco	*Tauraco porphyreolophus*	x	x		

Family	Species	Scientific name	TABAP	KVWP	Breeding	Notes
Cuculidae	Barred Long-tailed Cuckoo	*Cercococcyx montanus*	x		b	
	Diederik Cuckoo	*Chrysococcyx caprius*	x	x		
	Emerald Cuckoo	*Chrysococcyx cupreus*		x		
	Klaas' Cuckoo	*Chrysococcyx klaas*	x			
	Levaillant's Cuckoo	*Clamator levaillantii*	x	x		
	Eurasian Cuckoo	*Cuculus canorus*	x			Eurasian migrant
	Black Cuckoo	*Cuculus clamosus*	x			
	African Cuckoo	*Cuculus gularis*	x			
	Red-chested Cuckoo	*Cuculus solitarius*	x			
	Yellowbill	*Ceuthmochares aereus*	x	x		
	Coppery-tailed Coucal	*Centropus cupreicaudus*	x	x		Brachystegia biome
	Black Coucal	*Centropus grillii*		x		
	Senegal Coucal	*Centropus senegalensis*	x		b	
	White-browed Coucal	*Centropus superciliosus*	x	x	B	subspp *superciliosus* & *burchelli*
Tytonidae	Barn Owl	*Tyto alba*	x	x	b	
Strigidae	Spotted Eagle Owl	*Bubo africanus*	x	x		
	African Wood Owl	*Strix woodfordii*	x	x	b	
	African Barred Owlet	*Glaucidium capense*	x	x	b	
	Pearl-spotted Owlet	*Glaucidium perlatum*	x			
	White-faced Scops Owl	*Otus leucotis*		x	b	
	Pel's Fishing Owl	*Scotopelia peli*	x	x		
Caprimulgidae	Gabon Nightjar	*Caprimulgus fossii*	x	x		
	Fiery-necked Nightjar	*Caprimulgus pectoralis*	x			
	Pennant-winged Nightjar	*Macrodipteryx vexillarius*	x			
Apodidae	Little Swift	*Apus affinis*	x	x	B	
	Eurasian Swift	*Apus apus*	x			Eurasian migrant
	Black Swift	*Apus barbatus*		x		
	White-rumped Swift	*Apus caffer*	x	x	B	
	Palm Swift	*Cypsiurus parvus*	x	x	B	
	Boehm's Spinetail	*Neafrapus boehmi*	x			

Family	Species	Scientific name	TABAP	KVWP	Breeding	Notes
	Mottle-throated Spinetail	*Telacanthura ussheri*	x	x		
Coliidae	Speckled Mousebird	*Colius striatus*	x	x		
Trogonidae	Narina Trogon	*Aploderma narina*	x	x	b	
Alcedinidae	Giant Kingfisher	*Megaceryle maxima*	x	x	B	
	Pied Kingfisher	*Ceryle rudis*	x	x	B	
	Malachite Kingfisher	*Alcedo cristata*	x	x	b	
	Half-collared Kingfisher	*Alcedo semitorquata*	x	x	B	
	Brown-hooded Kingfisher	*Halcyon albiventris*	x	x	B	
	Striped Kingfisher	*Halcyon chelicuti*	x	x		
	Chestnut-bellied Kingfisher	*Halcyon leucocephala*	x	x		
	Pygmy Kingfisher	*Ispidina picta*	x	x	b	
Meropidae	Eurasian Bee-eater	*Merops apiaster*	x			Eurasian migrant
	Boehm's Bee-eater	*Merops boehmi*	x	x		Brachystegia biome
	White-fronted Bee-eater	*Merops bullockoides*	x	x	B	
	Swallow-tailed Bee-eater	*Merops hirundineus*	x			
	Blue-cheeked Bee-eater	*Merops persicus*	x			
	Little Bee-eater	*Merops pusillus*	x	x		
	Madagascar Bee-eater	*Merops superciliosus*	x	x		
Coraciidae	Lilac-breasted Roller	*Coracias caudata*	x	x	B	
	Eurasian Roller	*Coracias garrulus*	x			Eurasian migrant
	Rufous-crowned Roller	*Coracias naevia*	x			
	Racquet-tailed Roller	*Coracias spatulata*	x			Brachystegia biome
	Broad-billed Roller	*Eurystomus glaucurus*	x			
Upupidae	Hoopoe	*Upupa epops*	x	x		subsp *africana*
	Scimitarbill	*Phoeniculus cyanomelas*	x	x		
	Green Wood Hoopoe	*Phoeniculus purpureus*	x	x		
Bucerotidae	Silvery-cheeked Hornbill	*Bycanistes brevis*	x	x		
	Trumpeter Hornbill	*Bycanistes bucinator*	x	x		

Family	Species	Scientific name	TABAP	KVWP	Breeding	Notes
	Crowned Hornbill	*Tockus alboterminatus*	x	x	B	subsp *suahelicus*
	Grey Hornbill	*Tockus nasutus*	x	x		
	Pale-billed Hornbill	*Tockus pallidirostris*	x			Brachystegia biome
	Southern Ground Hornbill	*Bucorvus cafer*	x	x		
Capitonidae	Spotted-flanked Barbet	*Lybius lacrymosus*		x		
	Black-collared Barbet	*Lybius torquatus*	x	x		
	Yellow-rumped Tinkerbird	*Pogoniulus bilineatus*	x			
	Yellow-fronted Tinkerbird	*Pogoniulus chysoconus*		x	B	
	Green Tinkerbird	*Pogoniulus simplex*	x			East African Coast biome
Indicatoridae	Greater Honeyguide	*Indicator indicator*	x	x		
	Lesser Honeyguide	*Indicator minor*	x	x		
Picidae	Red-throated Wryneck	*Jynx ruficollis*	x			
	Golden-tailed Woodpecker	*Campethera abingoni*	x			
	Little Spotted Woodpecker	*Campethera caillautii*	x	x		
	Cardinal Woodpecker	*Dendropicos fuscescens*	x	x		
	Stierling's Woodpecker	*Dendropicos stierlingi*	x	x		**nt**, Brachystegia biome
Eurylamidae	African Broadbill	*Smithornis capensis*	x	x		
Alaudidae	Flappet Lark	*Mirafra rufocinnamomea*	x	x		
Hirundinidae	House Martin	*Delichon urbica*	x			Eurasian migrant
	Striped Swallow	*Hirundo abyssinica*	x	x	B	
	Red-rumped Swallow	*Hirundo daurica*	x			
	African Rock Martin	*Ptyonoprogne fuligula*	x			
	Grey-rumped Swallow	*Pseudhirundo griseopyga*	x	x	B	
	Eurasian Swallow	*Hirundo rustica*	x			Eurasian migrant
	Mosque Swallow	*Hirundo senegalensis*	x			
	Wire-tailed Swallow	*Hirundo smithii*	x	x	B	
	Black Saw-wing	*Psalidoprocne pristoptera*	x	x		
	Banded Martin	*Riparia cincta*	x			

Family	Species	Scientific name	TABAP	KVWP	Breeding	Notes
	African Sand Martin	*Riparia paludicola*	x	x	B	
	Sand Martin	*Riparia riparia*	x			Eurasian migrant
Motacillidae	African Pipit	*Anthus cinnamomeus*	x	x		
	Yellow-throated Longclaw	*Macronyx croceus*	x	x		
	African Pied Wagtail	*Motacilla aguimp*	x	x	b	
	Mountain Wagtail	*Motacilla clara*	x		B	
	Yellow Wagtail	*Motacilla flava*	x			Eurasian migrant
Campephagidae	Black Cuckoo Shrike	*Campephaga flava*	x	x		
	Grey Cuckoo Shrike	*Coracina caesia*	x			
	White-breasted Cuckoo Shrike	*Coracina pectoralis*	x	x		
Pyconotidae	Slender-billed Greenbul	*Andropadus gracilirostris*	x			
	Zanzibar Sombre Greenbul	*Andropadus importunus*	x	x		
	Mountain Greenbul	*Andropadus nigriceps*	x			
	Little Greenbul	*Andropadus nitens*	x	x		
	Yellow-bellied Greenbul	*Chlorocichla flaviventris*	x		b	
	Nicator	*Nicator gularis*	x		b	
	Fischer's Greenbul	*Phyllastrephus fischeri*	x		b	East African Coast biome
	Yellow-streaked Greenbul	*Phyllastrephus flavostriatus*	x			
	Common Bulbul	*Pycnonotus barbatus*	x	x	b	
Turdidae	White-browed Scrub Robin	*Cercotrichas leucophrys*	x			
	Eastern Bearded Scrub Robin	*Cercotrichas quadrivirgata*	x	x	b	
	Morning Thrush	*Cichladusa arquata*	x	x		
	White-browed Robin Chat	*Cossypha heuglini*	x	x		
	Red-capped Robin Chat	*Cossypha natalensis*	x	x		
	Miombo Rock Thrush	*Monticola angolensis*	x			Brachystegia biome
	Capped Wheatear	*Oenanthe pileata*		x	b	
	White-starred Forest Robin	*Pogonocichla stellata*	x			
	Stonechat	*Saxicola torquata*	x	x		
	White-headed Black Chat	*Thamnolea arnotti*	x			
	Orange Ground Thrush	*Turdus gurneyi*	x	x		

Family	Species	Scientific name	TABAP	KVWP	Breeding	Notes
	Kurrichane Thrush	*Turdus libonyana*	x			
Sylviidae	African Reed Warbler	*Acrocephalus baeticatus*	x			
	Lesser Swamp Warbler	*Acrocephalus gracilirostris*	x	x		
	Sedge Warbler	*Acrocephalus schoenobaenus*	x			Eurasian migrant
	Yellow-breasted Apalis	*Apalis flavida*	x	x	b	
	Black-throated Apalis	*Apalis jacksoni*	x			
	Little Rush Warbler	*Bradypterus baboecala*	x			
	Grey-backed Camaroptera	*Camaroptera brachyura*	x	x		
	Yellow Warbler	*Chloroptera natalensis*	x			
	Singing Cisticola	*Cisticola cantans*	x			
	Rattling Cisticola	*Cisticola chiniana*	x	x	B	
	Chubb's Cisticola	*Cisticola chubbi*	x			
	Red-faced Cisticola	*Cisticola erythrops*	x		b	
	Winding Cisticola	*Cisticola galactotes*	x			
	Cisticola No. 1	*Cisticola sp.*	x	x	b	**nt?**, Brachystegia biome
	Cisticola No. 2	*Cisticola sp.*	x	x	b	**DD**?, Brachystegia biome
	Green-capped Eremomela	*Eremomela scotops*	x	x		
	Red-winged Warbler	*Heliolais erythroptera*	x			
	Yellow-bellied Hyliota	*Hyliota flavigaster*		x		
	Willow Warbler	*Phylloscopus trochilus*	x			Eurasian migrant
	Tawny-flanked Prinia	*Prinia subflava*	x	x		
	Moustached Warbler	*Sphenoeacus mentalis*	x	x		
	Whitethroat	*Syvlia communis*	x			Eurasian migrant
	Red-faced Crombec	*Sylvietta whytii*		x		
Muscicapidae	Pale Flycatcher	*Bradornis pallidus*	x	x	b	
	Southern Black Flycatcher	*Melaenornis pammelaina*	x			
	Dusky Flycatcher	*Muscicapa adusta*	x			
	Ashy Flycatcher	*Muscicapa caerulescens*	x	x		
	Spotted Flycatcher	*Muscicapa striata*	x			Eurasian migrant
	Lead-coloured Flycatcher	*Muscicapa plumbea*	x			
Platysteiridae	Chin-spot Batis	*Batis molitor*	x			

Family	Species	Scientific name	TABAP	KVWP	Breeding	Notes
	Black-headed Batis	*Batis minor*		x		
	East Coast Batis	*Batis soror*	x	x		East African Coast biome
	Black-throated Wattle-eye	*Platysteira peltata*	x	x		
	Black & White Flycatcher	*Bias musicus*	x	x		
Monarchidae	Livingstone's Flycatcher	*Erythrocercus livingstonei*		x		
	African Paradise Flycatcher	*Terpsiphone viridis*	x	x	b	
	Crested Flycatcher	*Trochocercus cyanomelas*	x	x		
Timaliidae	Arrow-marked Babbler	*Turdoides jardineii*	x	x		
	Black-lored Babbler	*Turdoides sharpei*	x			
Paridae	Rufous-bellied Tit	*Parus rufiventris*	x	x		Brachystegia biome
Nectarinidae	Collared Sunbird	*Hedydipna collaris*	x	x	b	
	Uluguru Violet-backed Sunbird	*Anthreptes neglectus*	x	x	b	East African Coast biome
	Amethyst Sunbird	*Chalcomitra amethystina*	x			
	Purple-banded Sunbird	*Cinnyris bifasciata*	x	x		
	Marico Sunbird	*Cinnyris mariquensis*	x			
	Eastern Olive Sunbird	*Cyanomitra olivacea*	x		b	
	Scarlet-chested Sunbird	*Chalcomitra senegalensis*	x	x		
	Shelley's Sunbird	*Cinnyris shelleyi*	x			Brachystegia biome
	Variable Sunbird	*Cinnyris venusta*	x	x		
Zosteropidae	Yellow White-eye	*Zosterops senegalensis*	x			
Laniidae	Red-backed Shrike	*Lanius collurio*	x			Eurasian migrant
Malaconotidae	Black-backed Puffback	*Dryoscopus cubla*	x	x		
	Tropical Boubou	*Laniarius aethiopicus*	x	x	b	
	Grey-headed Bush-Shrike	*Malaconotus blanchoti*		x		
	Many-coloured Bush-Shrike	*Malaconotus multicolor*	x			
	Orange-breasted Bush-Shrike	*Malaconotus sulfureopectus*	x	x		
	Brubru	*Nilaus afer*		x	b	

Family	Species	Scientific name	TABAP	KVWP	Breeding	Notes
	Brown-crowned Tchagra	*Tchagra australis*	x			
	Black-crowned Tchagra	*Tchagra senegala*	x	x	b	
	Three-streaked Tchagra	*Tchagra minuta*	x			
Prionopidae	White Helmet-shrike	*Prionops plumatus*	x	x		
	Retz's Helmet-shrike	*Prionops retzii*	x	x	b	
Oriolidae	African Golden Oriole	*Oriolus auratus*	x	x	b	
	Black-headed Oriole	*Oriolus larvatus*	x	x	b	
	Golden Oriole	*Oriolus oriolus*	x			Eurasian migrant
	White-necked Raven	*Corvus albicollis*	x			
Dicruridae	Fork-tailed Drongo	*Dicrurus adsimilis*	x	x		
	Square-tailed Drongo	*Dicrurus ludwigii*	x	x		
Corvidae	Pied Crow	*Corvus albus*	x	x		
	Indian House Crow	*Corvus splendens*	x			
Sturnidae	Violet-backed Starling	*Cinnyricinclus leucogaster*	x	x		
	Lesser Blue-eared Starling	*Lamprotornis chloropterus*	x			
	Black-bellied Glossy Starling	*Lamprotornis corruscus*	x			East African Coast biome
	Yellow-billed Oxpecker	*Buphagus africanus*	x	x		
	Red-billed Oxpecker	*Buphagus erythrorhynchus*	x			
Ploceidae	Red-headed Weaver	*Anaplectes rubriceps*	x	x		
	Red-collared Widowbird	*Euplectes ardens*	x		b	
	Fan-tailed Widowbird	*Euplectes axillaris*	x	x	b	
	Yellow Bishop	*Euplectes capensis*	x	x	b	
	Black-winged Red Bishop	*Euplectes hordaceus*	x			
	Zanzibar Red Bishop	*Euplectes nigroventris*	x			East African Coast biome
	Southern Red Bishop	*Euplectes orix*	x	x	B	
	Dark-backed Weaver	*Ploceus bicolor*	x	x	B	
	Kilombero Weaver	*Ploceus burnieri*	x	x	b	**VU**, Brachystegia biome
	Village Weaver	*Ploceus cucullatus*	x	x		

Family	Species	Scientific name	TABAP	KVWP	Breeding	Notes
	Spectacled Weaver	*Ploceus ocularis*	x	x		
	Golden Weaver	*Ploceus subaureus*	x	x	B	
	Cardinal Quelea	*Quelea cardinalis*	x			
	Red-headed Quelea	*Quelea erythrops*		x		
	Red-billed Quelea	*Quelea quelea*		x		
	White-browed Sparrow Weaver	*Plocepasser mahali*	x			
	Red-billed Buffalo Weaver	*Bubalornis niger*		x		
	House Sparrow	*Passer domesticus*		x		subsp *indicus*
	Grey-headed Sparrow	*Passer griseus*	x	x		
	Yellow-throated Petronia	*Petronia superciliaris*	x	x		
Viduidae	Village Indigobird	*Vidua chalybeata*	x	x		
	Purple Indigobird	*Vidua purpurascens*	x			
	Pin-tailed Whydah	*Vidua macroura*	x	x	b	
	Broad-tailed Paradise Whydah	*Vidua obtusa*		x	b	Brachystegia biome
	Paradise Whydah	*Vidua paradisaea*	x		b	
Estrildidae	Zebra Waxbill	*Amandava subflava*	x	x		
	Common Waxbill	*Estrilda astrild*	x	x		
	Yellow-bellied Waxbill	*Estrilda melanotis*		x		
	Fawn-breasted Waxbill	*Estrilda paludicola*	x			
	Peters' Twinspot	*Hypargos niveoguttatus*	x			
	African Firefinch	*Lagonosticta rubricata*	x	x	B	
	Red-billed Firefinch	*Lagonosticta senegala*	x	x	B	
	Green-backed Twinspot	*Mandingoa nitidula*	x		b	
	Lesser Seed-cracker	*Pyrenestes minor*	x		b	
	Orange-winged Pytilia	*Pytilia afra*		x		
	Green-winged Pytilia	*Pytilia melba*	x	x		
	Southern Cordonbleu	*Uraeginthus angolensis*	x	x	b	
	Red-cheeked Cordonbleu	*Uraeginthus bengalus*	x			
	Black & White Mannikin	*Lonchura bicolor*	x	x		subspp *nigriceps*
	Bronze Mannikin	*Lonchura cucullata*	x	x	B	
	Magpie Mannikin	*Lonchura fringilloides*	x			

Family	Species	Scientific name	TABAP	KVWP	Breeding	Notes
Emberizidae	Cinnamon-breasted Rock Bunting	*Emberiza tahipisi*	x	x		
Fringillidae	Yellow-fronted Canary	*Serinus mozambicus*	x	x		

372 species

Section 3
Mammal survey

Top: Zebras in wooded grassland. In the early dry season they were seen in relatively small herds, but later on they were seen in groups of 60 or more. The wooded grassland area contains the highest number of mammal species. Increasing numbers of cattle could possibly change the ecology of this area considerably.
Bottom: Young male puku in a short grass area. Puku are confined to areas of low-lying short grassland, where they sometimes occur at extremely high densities. However, their distribution is patchy, even within suitable habitat, so point counts rather than transects are a suitable monitoring method.

Section 3: Large mammal survey

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Introduction

The original reason why the Kilombero Valley was gazetted as a conservation area was that it contains high densities of game animals. This is reflected in the conservation category that was applied – namely 'Game Controlled Area', which regulates only hunting of large mammals and not fishing or land use. Aerial surveys show that the valley still contains large populations of large mammals. In the mid-1980's hunting for ivory considerably depleted the population of elephants, but following a major anti-poaching operation, elephants appear to be increasing again. When this study was conceived there was concern in the Wildlife Division and among other conservation organisations that levels of hunting in the Kilombero Valley had increased once more, though this time targeting ungulates for a trade in wild meat. However, there was little real information on the situation in the area.

Aerial surveys carried out by Tanzania Wildlife Conservation Monitoring/Frankfurt Zoological Society appear to show the populations of some species declining over the last ten years, especially elephant and zebra (Table 1). Populations of other species appear to have remained stable, still others, such as puku, appear to have fluctuated wildly. However, the surveys have covered different areas at different times each year and so are not strictly comparable. Many of the figures have error margins almost as large as the figures themselves. Even in the same year different aerial surveys have produced wildly different results. For example in 1991, the Selous Game Reserve aerial census estimated 1898 elephants in the valley, whilst the Tanzania Elephant Census estimated 5000. These figures indicate that in reality little is known of the population size and status of the large mammals in the valley. This study was therefore conceived with the aim of investigating the population size, distribution and status of large mammals in the Kilombero Valley.

Table 1: Population sizes of large mammals in the Kilombero valley based on aerial surveys

Species	*1976*	*October 1986*	*September 1989*	*June 1991*
Buffalo	39380 ± 14073	59260 ± 19793	30 494 ± 7530	35301 ± 9673
Elephant	5848 ± 1228	2330 ± 640	995 ± 144	1848* ± 512
Hippo	4442 ± 1326	6044 ± 502	8414 ± 2594	5413 ± 1705
Puku	26427 ± 6644	43670 ± 13354	55760 ± 19428	36560 ± 13133
Sable	1295 ± 999	1127 ± 707	–	687 ± 390
Zebra	6107 ± 5161	1919 ± 1042	976 ± 570	716 ± 393
Eland	–	–	7 46 ± 554	185 ± 171
Hartebeest	–	–	140 ± 73	345 ± 297
Lion	–	–	–	29± 28
Reedbuck	–	–	494 ± 221	89 ± 46
Warthog	–	–	2920 ± 589	1291 ± 272
Wild pig	–	–	–	28 ± 30
Waterbuck	–	–	162 ± 117	–

* *The 1991 Tanzania Elephant Census estimated 5000 elephant in the valley.*

Source: Tanzania Wildlife Division Censuses, taken from WWF (1992).

Aims and methodology

Of the species that have been surveyed by aerial census, only the figures for buffalo, elephant and puku appear to be in any way meaningful. For the other species, sample sizes are too small and the area surveyed so large, that the error margins are too large for the figures to be useful. For elephant, the counts are probably fairly accurate, since they are easily visible. However, elephants do appear to move regularly in and out of the valley into the surrounding highlands and the Selous Game Reserve (UDNRO 1997), and since the counts have not been taken at the same time of year, they can only give very rough information on trends over time. Puku never move far from the floodplain, making them highly amenable to aerial census. However, their distribution in the valley is very patchy, for example see the map of puku distribution in Rodgers (1984). Unless this uneven distribution is taken into account, population estimates can be distorted, and at the very least, the error margins of the estimate will be large. This is reflected in the error margins given in the table above, which are of the order of 30 to 40% of the total estimate. Although such estimates can probably provide information on long-term trends, and would show any major population crashes or increases, they are of little use for monitoring populations more accurately, as would be required for assessing the success of a community-based conservation programme, or the sustainability of yields from a cropping scheme.

The aims of this study were therefore to use ground transects to collect more detailed data on the population sizes, structure and distribution of the large mammals of the valley in order to assess the population status and to propose a monitoring scheme to provide information for future conservation management.

To this end we carried out 24 foot transects, covering a total of 191 km in the Ulanga District side of the valley. The locations of each transect are shown in Map 1 overleaf. Difficulties in entering and moving in the floodplain and a limited period of research meant that transects were not located randomly, but were selected to cover representative areas of the valley including all the different plant communities. We decided that this was a more effective use of our resources than a detailed random design would be. Our intention was that even if the transects were not strictly random, repeat surveys along the same routes would allow monitoring of changes in population density and distribution over time.

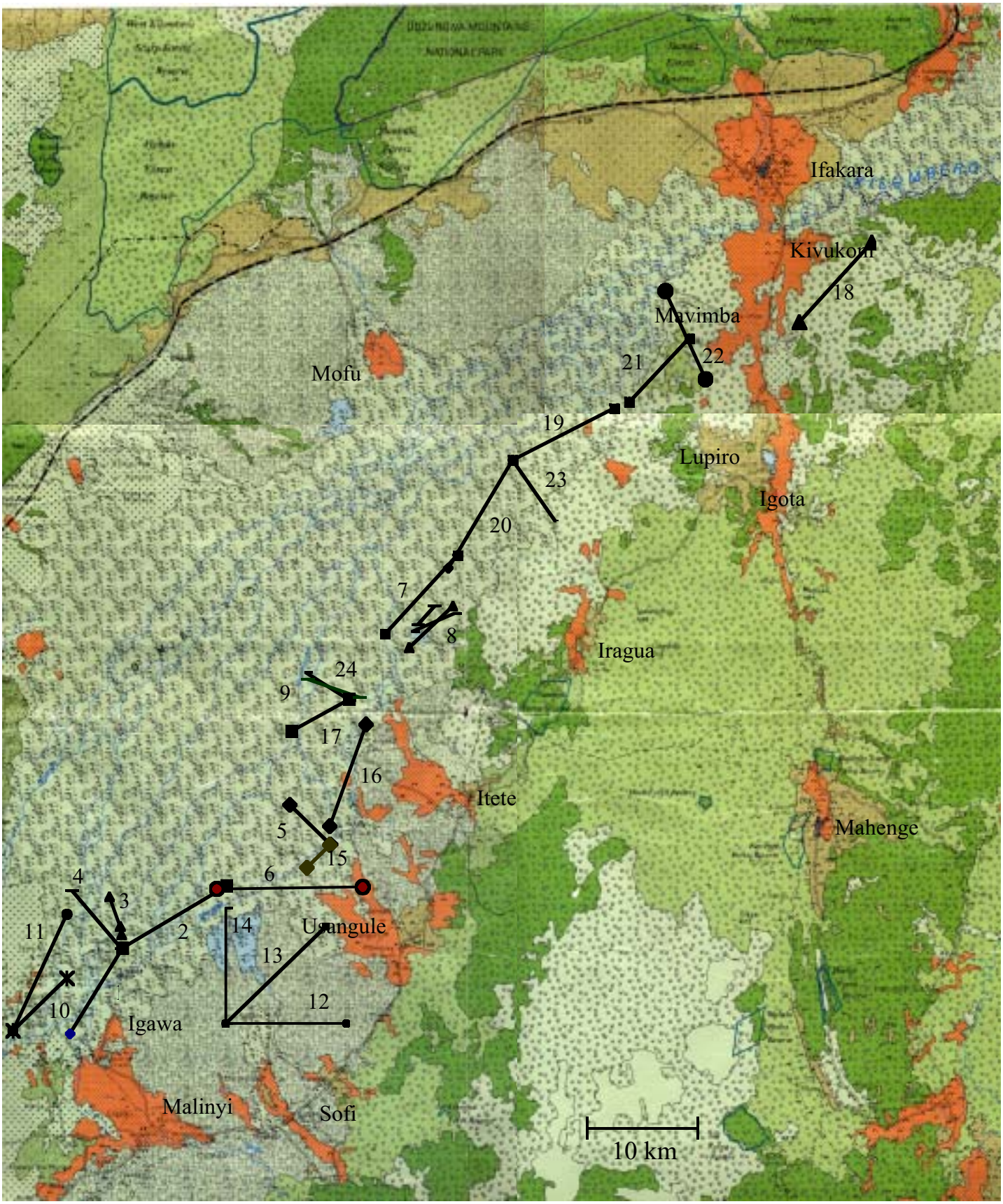
Transects were approximately 10 km in length and were started soon after dawn. Three or more people moved slowly along the transect and all animals seen were recorded. One of the members of each group was trained in the method of determining plant communities described in the botanical section, and the position of each change of vegetation zone was recorded. For all animals seen, the species, number in the group, sex of each animal, sighting angle and an estimate of distance to the group were recorded. In the absence of a rangefinder (since they were too expensive), and the fact that it was impossible to measure distances to some animals without disturbing others, distances were estimated. A series of trials using a GPS indicated that there was considerable variance in estimates of distance by individual observers, but that a compromise between the estimations of each observer was relatively accurate (but see below).

Distance analysis

Distance analysis is a set of statistical methods used to analyse line transect data. A key problem with transect counts is that the probability of sighting an animal decreases (sometimes rapidly) with distance from the observer, making an estimate of the effective transect width difficult. Distance analysis aims to overcome this problem by using information on the distance of animals seen from the transect line to estimate the probability of seeing an animal at a given distance and correcting the calculated density for this. The method is very powerful and can produce precise (as opposed to accurate) estimates of density, but it therefore has stringent statistical and observation requirements, including the necessity of counting all animals seen directly on the transect line, and that a minimum of 80 observations are made. We originally planned to use distance analysis for our transect data and so we collected data to calculate perpendicular distances.

Discussion of methods

As will be evident from the discussion below, the transect method was not as effective as we hoped. This was partly due to the difficulties inherent in attempting to survey a large area which is highly heterogeneous in terms of vegetation and hence visibility of animals, in a short time and with limited



Map 1. Map showing the position of the mammal transects.

personnel. Nevertheless, we recognise that part of the problem was that the area we attempted to cover was too large, that the aims were too broad and that the study was not planned in enough detail. However the process of carrying out the transects has given us a detailed qualitative knowledge of the distribution and abundance of large mammals, if not the detailed quantitative information initially hoped for. Moreover, the lessons we have learnt are instructive for the design of future monitoring programmes, and in this at least the data is of considerable value. Some of the problems we encountered are discussed below and in each section on individual species. A final discussion uses our experiences to suggest a possible future monitoring programme.

Of the animals seen only puku, warthog and zebra appear to have enough observations to make distance analysis appropriate. However, for species that occur in herds or groups, the correct unit of analysis for distance analysis is the number of sightings of groups rather than of individuals and account needs to be taken of this. Each of these three species occurred in groups, and for zebra and warthog there were an insufficient number of sightings to meet the statistical requirements for distance analysis, especially when the data were disaggregated by vegetation type. Distance analysis was therefore inappropriate for the analysis of the zebra and warthog data. It was also decided that distance analysis was inappropriate for the analysis of the puku sightings because of their patchy distribution and the discontinuous change of detection probability and density of animals between long and short grass (see discussion below), since distance analysis is designed for use when the detection probability is constant along the length of the transect (or rather the distribution of detection probabilities are constant and continuous).

Results

Eleven species of wild mammal were seen on the transects as well as cattle and goats. The total number of animals seen and the number of transects on which they were seen are shown in Table 2 below

Table 2: Total number of each species seen

Species	Total seen	Number of transects on which seen (total=24)
Buffalo	108	6
Bushbuck	1	1
Cattle	2981	10
Eland	32	3
Elephant	3	3
Goats	171	4
Litchenstein's hartebeest	3	1
Puku	2215	20
Common reedbuck	10	5
Warthog	151	14
Waterbuck	1	1
Zebra	377	10

Table 3: Number of animals of each species seen on each transect													
Transect number	Buffalo	Bushbuck	Cattle	Eland	Elephant	Goats	Hartebeest	Hippo	Puku	Reedbuck	Warthog	Waterbuck	Zebra
1									20		7		
2			250						34		25		9
3					2				175		13		
4			468						23		59		
5	0				1				6		3		
6			360						20		7		
7	80		200	1					584		8		6 4
9									105				
10	25		200					1	3				
11	1												
12			401			81	3		38	1			3 1
13			250						37		8		3 3
14			247			12							5
15													
16			205		0	8			1				
17									124	1	1		
18											0		
19	2			1					5	3	5		2 0 3
20			400			70			221	2	9		
21													
23	0								9		3		1 9
24									778	3			2
31									21		2		
81									14			1	
83									3				7
84		1		30					15		3		4
232									2	2	3		

Summary of findings by species

Puku

Puku were seen on 20 out of the 24 transects, but their distribution was highly uneven. The majority of puku (96%) were seen in short grass areas, with most of these (1803 out of 2236 individuals) seen on only four transects totalling 40.6 km all of which were in low-lying valley grassland and marginal grassland vegetation zones (see Botanical report for more details). The majority of the rest (76 individuals or 4%) were seen in marginal woodland areas, with none seen in miombo woodland and only very few in combretaceous wooded grassland (and the ones that were seen there were in small patches of shorter grass). In short grass areas many puku were in large groups of up to 41 animals, though in some places (notably the region nicknamed 'Serengeti'), the density of animals was so high that it was sometimes difficult to tell different groups apart. The largest groups were mostly of female animals with one or two males, although there were also bachelor herds of up to 26 males. Of the male puku 249 or 39% were seen singly or in all-male groups. Of these 85 were lone males, most of which were seen in wooded grassland areas. 164 males were in bachelor groups with a mean group size of 6.6±1.3 with a maximum of 26, mostly in short grass areas.

Forty-six female puku (3%) were seen singly, and total of 515 females or 37% of all females were seen in female-only groups, with a mean group size of 6.2±0.71 and a maximum of 41. However, the majority (59%) of females were in mixed sex groups, with an average size of 8.6 ±0.98.

The distribution of group sizes is very similar to that found by Rodgers in the Kilombero Valley in 1978, and to the group sizes found in Luwangwa Valley National Park and Kasanka National Park in Zambia (Goldspink et al 1998; Rosser 1992), though there appear to be slightly more puku in groups of 25 or more in the Kilombero Valley.

Puku density and distribution

In short grass areas, distance analysis of our transect data to produce density estimates was inappropriate because 1) puku were very patchily distributed within and between short grass areas and 2) the patchy nature of the vegetation with areas of short grass surrounded by more-or-less impenetrable short grass results in an abrupt change both in visibility and density between short grass and

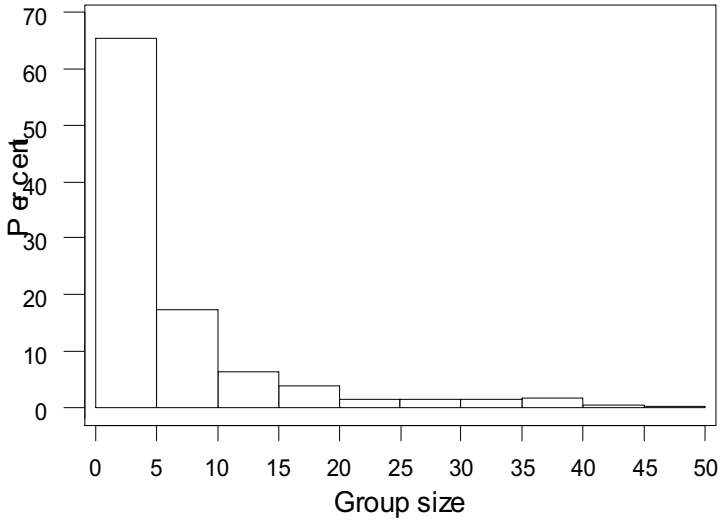


Figure 1: Histogram showing the number of puku occurring in groups of different sizes

long grass (ie all puku present are seen in short grass, and none in long grass; there are probably few puku in long grass) and considerable changes in the maximum detection distance along the transect which would bias the results considerably. The only way to calculate realistic densities of puku in short grass would be to count all puku in a given short grass area and then to estimate the area of the patch of short grass (eg by circumnavigating it and recording its shape and size with a GPS or compass and measuring tape). This method has been used successfully by Rosser (1992) and Goldspink et al (1998) for studying puku in Zambia.

Distance analysis would be appropriate for determining the density of puku in the wooded grassland areas where visibility was more consistent and sightings would certainly decline gradually with distance with distance. However, only 76 animals in 24 groups were seen in wooded grassland areas, an insufficient number to meet the statistical requirements for distance analysis.

We therefore suggest that, as other studies have also found, transect sampling is inappropriate for estimating the density of puku and total counts in short grass areas are most likely to be effective.

Population size and trends

The aerial surveys suggest that the population of puku in the Kilombero Valley is somewhere between 25,000 and 55,000. However, the highly uneven distribution of puku means that these figures could be overestimates. The surveys use a standard methodology of counting all animals seen in a number of fixed-width strips of land and extrapolating this data to the uncounted areas to determine the total population size. The occurrence of high densities of puku in some patches and none in others could easily bias the results of the aerial surveys. For example, if in one year an aerial transect happened to coincide with a high-density area, this could lead to a high population estimate. In another year, if the high-density areas where not included then the calculated population size could appear to be much lower. In our transects, we covered probably the majority of areas on that side of the valley that contained high densities of puku, and saw a total of 2236 animals. There are almost certainly other large areas of short grass containing many puku, but we still find it difficult to imagine that there could be 25,000 puku on the Ulanga side of the flood plain. We therefore suggest that the results of the aerial surveys to date are probably at best unreliable, and at worst could be misleading as a result of trying to extrapolate densities from data on a patchy distribution. All the fluctuations in puku numbers that the aerial survey data suggest could in fact be the results of statistical anomalies.

The implication for monitoring via aerial surveys is that they need to take better account of the ecology of the species being monitored. In the case of puku, this would mean taking explicit account of their highly patchy distribution and attempting to achieve a total count of puku in areas of suitable habitat rather than extrapolate densities from a sample survey.

Sex ratio

The sex ratio of animals seen was biased in favour of females. Of 1974 puku over 1 year old whose sex was recorded, 68% were females, corresponding to a sex ratio of 1:2.1 males:females. However, the sex of 209 puku was not recorded for various reasons (animals fleeing before they were identified as males or females, etc), if these were mostly male the proportion of females could be as low as 61%, or if the unrecorded animals were mostly females, could be as high as 71%, giving a range of possible sex ratios between 1:1.56 and 1:2.44.

Other surveys of puku in Botswana and Zambia all found sex ratios biased towards females (Goldspink et al 1998; Rosser 1992). These studies found ratios of 1:3.5 in Kasanka National Park Zambia, 1:2.0-8.0 in Luwangwa National Park in Zambia and 1:4.0 in the Kafue Flats in Zambia and 1:1.49-1.64 in Botswana (Goldpsink et al 1998), so our figure lies at the lower end of the range of values seen. Goldspink et al (1998) interpreted the ratio of 1:3.5 males to females in Kasanka National Park in Zambia as representing the results of selective poaching pressure on males since they were less vigilant and occurred in smaller groups than females and so easier to hunt. Although the sex ratio of the puku we saw in Kilombero was biased towards females, it would be premature to attribute this to the effects of poaching because:

1) We do not know how well sample of puku we saw represents the total population. It may have been easier to see females rather than males, as males appeared to be more dispersed – 76 males (4%) were seen in wooded grassland areas, but very few females were seen here. It is therefore possible that the there were significant numbers of males in the wooded grassland areas that were not recorded in this survey. Without an accurate determination of the proportion of the total population of puku found outside short grass areas, we cannot estimate a sex ratio of the population as a whole.

The proportion of the population in wooded grassland areas is likely to be relatively small, so there may well still be a biases sex ratio, but it may be less than it at first appears from our data.

2) The same factors that make male puku more susceptible to hunting may make them more susceptible to natural predation as well. Since there appeared to be a considerable density of lion in the Kilombero Valley, this could also produce a biased sex ratio in adult puku.

3) Local people expressed a preference for the meat of female puku, saying that it was 'sweeter' and more tender, with the meat of pregnant females the most highly prized. If this is reflected in hunting practices, then it is unlikely that there is selective hunting of male puku.

We therefore suggest that there probably is a real bias in favour of females in the sex ratio, but we reserve our judgement on whether this is caused by selective hunting of males. The range of sex ratios we found is in fact at the lower end of the range of values found in other areas (Goldspink et al 1998), and if the bias is due to hunting, offtakes may be lower in the Kilombero Valley than elsewhere, though it may still have a noticeable effect on the population. Alternatively, hunters may be less selective of the sex of their prey in the Kilombero Valley.

Monitoring puku numbers

Puku are a flagship species for the Kilombero Valley – although they occur as far south as Botswana, and there are significant populations in Zambia, the Kilombero Valley contains one of the largest individual populations, and one of only two in Tanzania. Puku are a key species targeted by hunters, and are also likely to be a key species in any cropping programme. Monitoring puku population densities is therefore important. In this section, we discuss potential methods for monitoring puku populations.

For example of the 2238 puku counted in this survey, 1800 (81%) were seen on four transects totalling 40.8 km, less than a quarter of the total. The implication of this is that the choice of transect line is very important – surveying two transects only a few hundred metres apart might record 0 and 1000 puku. To reduce the number of transects required for monitoring puku, it would therefore be advisable to use transects only in suitable puku habitat. However, even within this habitat puku have a highly clumped distribution – some small patches of suitable habitat contain considerable numbers of puku, whilst others do not, and in large areas of suitable habitat, parts are densely filled with puku and others are not. If transects are to be used to monitor numbers, this means that a considerable number of transects would need to be carried out to take account of the variation in density both within and between patches. The effort required to obtain meaningful data would therefore be considerable and probably prohibitive.

Given that puku seem to occur almost entirely in a single habitat type where visibility is good, point counts in which all puku visible from a certain point are counted are probably more likely to be an effective tool for monitoring. The advantages of this method are that 1) it overcomes the problems with the patchy distribution of puku, 2) data analysis would be far simpler, 3) it would require less effort and manpower at probably a lower cost, 4) as a result, repeat counts would be easier to make.

A potential method for such monitoring would be to use a 4WD vehicle to drive into suitable areas of puku habitat near and far from villages (both occupied and currently unoccupied) and conduct total counts at designated fixed points from the roof of the vehicle. In this way, a considerable number of total counts could be carried out in a single day. In an initial survey, several repeat counts should be made at a subset of the selected count points (perhaps twice a day every day for 5 days) to assess the level of diurnal and day-to-day variation in puku occupancy of selected habitat to ensure that multiple counts carried out on the same day are really valid. The results of this would allow an assessment of the number of repeat counts that would need to be made at each point to take account of day-to-day variation.

After an initial survey, point counts could be carried out at the same time each year to monitor population changes. The points chosen should include both large areas of suitable habitat where the bulk of the puku are found, and areas of suitable habitat near villages and pastoralist bomas where there are currently puku. The areas near villages and bomas would provide a sensitive indicator of population reductions, as these are the areas where hunting or disturbance is most likely to be intense, and so the areas where the population might decline most quickly. A comparison of changes in densities over time in areas which are thought to be intensively hunted or where there are cattle and areas that are little hunted and little disturbed could indicate the extent to which hunting and presence of cattle affect puku numbers. However, it should be noted that we found

racks for drying meat in some remote areas of the floodplain, so it must be assumed that hunting may occur throughout the floodplain.

As discussed above, if aerial surveys were specifically designed to monitor puku populations, a total count of puku numbers from the air could be an effective and quick method of obtaining data.

Zebra

Zebra were seen on 10 transects, and all sightings were in the marginal woodland. Of the 377 zebra seen, 203, were seen on one transect, with two herds of 61 and 65 animals making up the majority of these. Given the mobility of zebras it is possible that these two herds were in fact the same group. Moreover, zebras had a clumped distribution, and were seen in herds of 2 – 65 animals, with a mean group size of 10.5 (standard deviation 11.3). Therefore the real unit of analysis should be the number of herds, but only 36 herds were seen, again insufficient to meet the statistical requirements for distance analysis and to estimate densities.

Transects in the wooded grassland areas would be an appropriate method to monitor zebra use of the area, but the relatively low population density indicates that a relatively large number of transects would be required to gain sufficient information. This would require considerable personnel and effort.

Warthog

Warthog were seen on 14 transects in marginal grassland, marginal woodland, low-lying valley grassland and combretaceous wooded grassland zones. A total of 36 groups were seen, with a mean group size of 3.3±0.5, with one large group of 14 animals. The number of groups is too small for distance analysis, and the differences in visibility between zones mean that other methods are not appropriate for calculating densities.

Elephant

Only three elephants were seen on the transects. However, elephant dung was commonly encountered, especially in miombo woodland, combretaceous wooded grassland and in denser areas of gallery forest. Dung was seen relatively rarely in the short grass areas and marginal woodland, but this may only represent a faster decay rate in these drier habitats with more exposure to sun. Elephants were regularly heard at night, especially around swampy areas. Ground transects based on visual sightings would not appear to be an appropriate method for monitoring elephant densities in the Kilombero Valley. On our transects, we recorded all elephant dung encountered, but the likelihood that the decay rate was considerably different between different vegetation zones, and the relatively fine scale of the mosaic of vegetation zones meant that it was impossible to compare relative densities between vegetation zones. Transects based on dung counts are therefore also unlikely to be an effective method for monitoring elephant populations in the Kilombero Valley. Establishing permanent plots such as 100 x 100m quadrats within each vegetation zone and monitoring dung density and decay rates in each plot would allow comparisons of elephant occupancy of each area to be made, and could possibly be used to monitor population trends. Whilst such methods would be appropriate for a scientific study of elephant ecology in the area, they are unlikely to be appropriate for long-term monitoring because the method requires 1) a considerable number of plots to take account of the different variables (vegetation zone, distance from habitation etc), 2) frequent repeat visits to each quadrat to count dung and monitor decay rates (and therefore expensive transport), 3) a relatively large team to carry out the fieldwork and 4) sophisticated data analysis. The fixed-plot dung count method would therefore seem to require too great an effort for the amount of information it would provide. Aerial counts, for all their disadvantages, are likely to be the most effective and cost-efficient method of monitoring elephants in the Kilombero Valley. These surveys can only reveal large-scale trends in the elephant population, but unless elephants start to be hunted for trophies this is probably sufficient for effective conservation management. However, it appears that the number of elephants in the valley varies considerably from season to season (UDNRO 1997), so it is important to ensure that annual surveys are carried out at the same time each year.

Buffalo

Several large herds of buffalo were seen both during the transects and other fieldwork. They were frequently heard in long grass areas, and could sometimes be seen from the roof of the landrover. Fresh dung was seen regularly in all vegetation zones, but particularly in long grass areas, and wooded grassland with a long grass understorey. Transect counts based on visual sightings are not an appropriate method for determining buffalo density and distribution because 1) they are mostly found in long grass areas where it is possible to be only a few feet away from them be unable to see them and 2) they occur in large herds within which it is

impossible to count individuals from ground level. Aerial counts are likely to be effective for monitoring buffalo numbers, but if they are to be able to record more than large rapid changes in population size, they need to be carried out more frequently and more regularly. As for elephant, the aerial surveys would need to be carried out at the same time of year each year, since both buffalo distribution and visibility change seasonally.

According to safari hunters, buffalo are regularly seen just outside the long grass in the centre of the valley very early in the mornings. A repeated survey of the number of buffalo seen each morning could provide a useful index of abundance. Dung counts are likely to be the only effective way of determining buffalo occupancy of different habitats with any accuracy. They could also be used to monitor changes in population size in the same way as described for above for elephants. However, the same limitations apply.

Eland

Eland were seen regularly in both marginal woodland and in combretaceous wooded grassland areas, though at low densities. A total of 32 sightings were made, with an average group size of 5.3±2.2. However, given the high mobility of eland, we cannot be certain that these were all independent sightings. We can therefore say only that eland are present, but at low densities. Eland appear to be revered spiritually by many people in the valley, and people claimed that they are never hunted.

Sable

The TWCM aerial surveys all suggest that considerable numbers of sable are found in the Kilombero Valley – for example the estimate was 687±390 in 1991. During our survey no sable were seen either during the transects or during many hours of botanical fieldwork spread all over the valley. Although sable are notoriously shy and difficult to see, we find it hard to believe that there can be that many sable in the valley. This view is reinforced by observations of safari hunters who have worked in the valley for many years and who have seen them only very rarely. It was suggested that from the air, hartebeest standing under trees with a dark shadow could be mistaken for sable. We believe that at the least, the data on sable numbers should be treated with caution.

Lion

Few lions were seen on the transects, though several were heard sleeping in clumps of long grass. Many were heard at night, and spoor was encountered frequently. The density of lions appears to be quite high, and safari hunters in the area suggest that it is possibly one of the highest densities in Africa but to determine this would require a far more detailed study than was possible for this project.

Hippopotamus

Hippos were (unsurprisingly) not seen on the transects, and we did not carry out a specific survey of hippos. Although no systematic study was carried out, many were seen on the rivers during the crocodile counts, and it was possible to get a general idea of their distribution. Hippos were encountered most frequently on smaller river channels at the south-western end of the valley. On larger river channels relatively few were seen and there appear to be few hippo from the boundary of the Selous Game Reserve, upstream to where the river splits into multiple channels, though there are some still present even close to the ferry at Kivukoni. We found several pools and swampy areas away from rivers, each of which contained up to 25 hippo.

Several wounded animals were seen, and hunting would appear to be common. Hippo were usually very scared at the approach of a boat, and submerged or left the river unless approached very closely. Hippo also appeared to spend a considerable proportion of each day out of the water, and fishermen reported that they often hid themselves in the long grass, or in small pools close to the rivers where people were less likely to go (ie where there were no passing canoes). Hunting appears to be mostly for use as bait for fishtraps, though several people told us that tusks were often kept and sold as false ivory. Hippos frequently cause injuries and deaths among fishermen (one fisherman was killed by an old bull hippo whilst we were in the valley) and as a result are greatly feared. It would probably be very difficult to gain popular local support for their conservation.

Assessing hippo population sizes is notoriously difficult – they can remain underwater for a considerable amount of time, and can travel large distances underwater. Moreover, the proportion of hippo that are not seen during each pass of a boat count or aerial counts can vary considerably, so these methods are frequently unreliable for monitoring unless many passes are made. In the Kilombero Valley, the existence of hippo in many small pools as well as in rivers makes either boat counts or aerial counts difficult – many pools are probably practically invisible from the air, and they can only be reached by foot. We suggest that the hippo

population figures based on the TWCM aerial counts are at best unreliable, and will only show very large changes in the number of hippos in the valley. It is almost certainly unrealistic to try to produce accurate estimates of the total hippo population in the valley. However, it would be possible to monitor population changes by using stationary observation platforms dispersed at selected points next to rivers in the valley. This method would require a considerable effort in terms of time and personnel. However, given that hippos probably play a very significant role in the floodplain ecology through keeping channels free of weed and so on, it is probably important to monitor their numbers to some extent. However, less frequent monitoring (eg every three years) would probably be sufficient and more frequent counts would only be worthwhile if it was necessary to monitor hippo populations closely, for example to assess the actual or potential sustainability of a monitoring scheme.

Other species

A few hartebeest, waterbuck, common reedbuck and bohor reedbuck were seen. The Kilombero Valley is in the overlap zone of the common and bohor reedbucks, so hair samples were taken from two carcasses found and given to the University of Dar-es-Salaam for their dna analysis programme. A complete list of the mammal species encountered whilst in the valley is in Appendix 1.

Discussion and conclusions

Although this study has provided some useful information on species distributions, it has not met its original aims of producing detailed estimates of mammal densities and population sizes. This is partly because it is in fact very difficult to determine these parameters for so many species at once in such a complex mosaic of habitats. However, it was also because the aims of the study were too broad and were relatively poorly defined. It would have been better to have focused on one or two particular species or vegetation zones and concentrated the available personnel on a study of these using species-specific survey methods. More detailed prior consultation with experts and the literature on the species involved would have also benefited the study. However, the lessons learned during this survey do provide us with a very useful background on which to base suggestions for a monitoring scheme for mammal populations in the valley.

Conservation of large mammals in the Kilombero Valley

As discussed in the introduction, the original reason for the gazettement of the Kilombero Valley and a major reason for its conservation interest was the presence of large numbers of large game species. In our study we have shown that considerable populations of game species continue to live in the Kilombero Valley. We do not have long-term data, and so cannot make suggestions as to how populations have changed. However, in this section we discuss the current threats to large mammal populations in the Kilombero Valley.

Effects of hunting on animal populations

Although we have no direct evidence of the effects of hunting, several factors suggest that hunting is widespread in the valley:

- Puku meat is regularly available in both Ifakara and village restaurants.
- Drying racks for meat were found in several areas of the valley.
- Ulanga District game scouts working with us found guns (including a highpowered .375 rifle), bullets (including home-made ‘hippo’ bullets for 12-bore shotguns), spears, wire and other hunting materials in camps along the rivers on several occasions. On one occasion a small camp had fresh carcasses of two puku and a buffalo, far more meat than would be needed for the people at the camp alone.
- A recently shot puku carcass (a pregnant female) was found and gun shots were heard on several occasions.
- At several fishing camps animal skins were being dried in the sun.

However, it should be stressed that we have no quantitative data on the levels of hunting and their impacts on animal populations. The current level of hunting may be sustainable, at least in many parts of the valley. Detailed and accurate knowledge of the effects of hunting can only come about through a comprehensive monitoring scheme, such as that suggested below. It is also essential to realise that **aggressive antipoaching**

action is likely to antagonise villagers and make it very difficult to build local support for conservation. It should also be remembered that most studies of the effectiveness of anti-poaching patrols have shown that **it is the probability of getting caught rather than the severity of the penalty that is the most effective deterrent**. The implication is that regular, low-key 'police-style' investigations with relatively mild penalties are likely to be far more effective than aggressive military-style actions once in a while.

Effects of changes in land use on animal populations

It is impossible to say definitively how changes in land use patterns are affecting wild animal populations from such a short study as this. However, from our social survey, it would appear that expansion of cropped area by villagers is not currently a significant threat to wild animals in the Kilombero Valley. It would be useful to investigate this in more detail, and we have returned the archival aerial photos of the valley that we purchased to the Ulanga District Council so that they are available for this.

Our socio-economic survey revealed that the number of pastoralists and their cattle in the valley appears to be increasing quite rapidly. As discussed in the social survey, there is evidence that pastoralists and wild animals can co-exist in many cases. However, in other cases, increasing numbers of pastoralists have been associated with significant declines and in some cases extirpation, of wild animal populations. We suggest that it is quite likely that if the number of cattle and pastoralists in the Kilombero Valley continues to increase, there will be declines in the numbers of wild animals, and especially puku, in at least some areas. However, we would like to stress that we do not have any detailed evidence for this at the present time, and that a detailed social and ecological study of pastoralism in the Kilombero Valley is an essential component for any conservation or development management plan. Whatever the findings of such a study, it is essential that pastoralists of all ethnicities are treated as legitimate stakeholders in any conservation or development scheme.

If the presence of pastoralists cattle is shown to be detrimental to populations of wild animals in the Kilombero Valley and this is perceived to be a significant conservation issue, then some action would need to be taken to reduce or limit the impact of pastoralists. We suggest that exclusionary conservation of the type in game reserves and national parks is probably inappropriate for the Kilombero Valley. Rather, a negotiated solution in which conservation-friendly and pastoralist-friendly grazing management regimes are implemented, voluntarily or perhaps through local bye-laws is more likely to be effective. This would have the advantage for the pastoralists in the valley to be guaranteed certain grazing rights, and for conservation of good relations with the pastoralists. If grazing rights are established and legitimised, the pastoralists themselves may have an incentive to attempt to restrict the immigration of new pastoralists, or at least pass information on to the appropriate authorities.

Kilombero District

It should be noted that we did not work in the Kilombero District side of the valley. Anecdotal evidence gain from conservations with people in the valley indicates that levels of hunting and pressures on wild animals are likely to be higher in this region. In particular, the larger resident population, easier access (by road and rail) and the presence of many relatively rich immigrant workers may contribute to more intense pressures on wildlife. There is therefore a need for a survey of animal population densities and hunting levels on the north western Kilombero District section of the valley. Ideally this should include 1) a reconnaissance air flight to identify areas of suitable puku habitat and to search for elephant carcasses, 2) an initial survey of puku numbers and distribution using the point count method described above, 3) a regular monitoring programme based on point counts as described above and 4) a socio-economic study of hunting and household dependence on wild meat in the villages bordering the valley in Kilombero District and 5) searches (but not arrests) on the TAZARA trains in both directions to assess the extent to which meat is sent out of the valley. These should be carried out as soon as possible. A socio-economic study of the extent to which wild meat is consumed in Ifakara should also be carried out.

The need for a monitoring scheme

Monitoring changes in population sizes of species of conservation concern is a fundamental requirement for effective management. Without an effective monitoring scheme, it is impossible to determine whether a conservation programme is being effective. Monitoring is especially important where animals are being cropped as part of the conservation scheme. However, it is a factor that is often forgotten or left out of conservation projects, and especially community-based conservation schemes and integrated conservation and development

projects. This is partly because monitoring can be complex to implement, and costly to carry out. However, careful attention to determining what monitoring data is to be used for can help designing monitoring programmes that are cost- and time-efficient. The following section first discusses what monitoring data might be necessary in the Kilombero Valley, and then suggests a possible monitoring scheme that could be compatible with a community-based conservation project.

Aims of monitoring

With any monitoring scheme there is necessarily a trade off between accuracy/precision of population estimates and the amount of effort required. It is therefore essential to determine at the outset what the data will be used for and thereby determine the level of precision required.

Monitoring of animal populations can be carried out for a variety of reasons including:

- To determine general population trends and especially significant declines in populations
- To determine a sustainable harvest level and to monitor the effects of harvesting
- To raise awareness of the distribution and abundance of animals to promote their conservation

For monitoring changes in abundance, proxy indicators can be used, and it is not necessary to determine the actual population size to any accuracy. However, for monitoring the effects of a harvesting programme and for determining potential quotas for harvesting, more accurate and precise data on population distribution, population size and structure is needed. For raising awareness about the presence or absence of certain species and to gain a general awareness of their distribution, methods do not necessarily have to be scientifically rigorous. However, if data from awareness-raising exercises are to be used to facilitate discussions at village level it is important that the data used is meaningful, otherwise problems may arise later for example if rigorous studies indicate that populations are changing, but awareness-raising studies do not show this.

In the Kilombero Valley the most important large mammal species to monitor would appear to be puku, elephant, hippo and buffalo, since these are probably the species that have the most conservation and ecological significance and which are most likely to be targeted by hunters.

The main conclusions we have drawn from this study are that:

- Current aerial surveys can only be relied on to show large-scale changes in the populations of elephants and buffalo, and presence/absence data on other ungulates. However, they are hampered in this because counts are not made at the same time each year.
- Aerial surveys may be producing highly misleading information on puku population sizes and changes in population sizes.
- Transect surveys are not an effective method for censusing or monitoring puku populations.
- Transect surveys could be effective for other ungulates in the woodland areas, but would require considerable effort and would probably be expensive.
- Puku could be censused by an aerial survey focused on achieving a total count of puku numbers in short grass areas.
- Puku populations could be monitored by point counts (total counts) in areas of suitable habitat.
- Dung counts could be effective for monitoring elephant and buffalo densities, but would be time-consuming, expensive and potentially dangerous in long grass areas.
- Hippos could be monitored from fixed sites, but this would be costly in terms of time and personnel

From the basis of our study we suggest that the aims of a monitoring programme for large mammals in the Kilombero Valley should be:

- To determine puku population numbers and distribution more accurately to assess potential harvest levels
- To monitor puku numbers and distribution
- To monitor elephant and buffalo populations for large scale changes
- To monitor hippo numbers for large-scale changes
- To monitor the presence or absence of other large ungulates in the marginal woodland areas

We therefore suggest that a monitoring programme should include:

- An aerial survey designed specifically to achieve a total count of puku numbers and distribution
- Annual monitoring of puku numbers in selected areas of suitable habitat both near and far from villages using total counts at specific locations
- Continued aerial monitoring of elephant and buffalo populations, but with an increased emphasis on ensuring that counts take place at the same time of year
- Monitoring of hippo populations using total counts from specific sites, with counts carried out possibly every two or three years rather than annually
- Continued monitoring of changes in trophy sizes for buffalo and puku.

More detailed studies of the ecology of large mammals, for example using elephant dung counts in several different vegetation zones and transect counts in the woodland areas would be very interesting and would probably yield useful data, however, the cost in terms of both money and expertise would be very high relative to the amount of information gained. Together, the highly-focused surveys suggested here would probably provide sufficient information to monitor changes in large mammal populations and to assess the sustainability of cropping programmes, and would do so at a relatively low cost. Such monitoring is essential for effective management of the mammal populations in the Kilombero Valley and for long-term conservation in the area.

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Appendix 1: Mammal species seen

This list contains all species observed in the valley by the team. Identifications and nomenclature are based on Kingdon (1997).

Carnivores

Lion	*Panthera leo*
Leopard	*Panthera pardus*
Serval	*Felis serval*
Spotted hyaena	*Crocuta crocuta*
Civet	*Civettictis civetta*
Banded mongoose	*Mungos mungo*
Bushy-tailed mongoose	*Bdeogale crassicauda*
Meller's mongoose	*Rhynchogale melleri*
Marsh mongoose	*Atilax paludinosus*
Clawless otter	*Aonyx capensis*
Honey badger	*Mellivora capensis*

Proboscids

Elephant	*Loxodonta africana*

Ungulates

Bush pig	*Potamochoerus africanus*
Warthog	*Phacochoerus africanus*
Hippopotamus	*Hippopotamus amphibius*
Common zebra	*Equus quagga*
Bush duiker	*Sylvicapra grimmia*
Puku	*Kobus vardoni*
Waterbuck	*Kobus ellipsiprymnus*
Bohor reedbuck	*Redunca redunca*
Southern reedbuck	*Redunca arundinium*
Bush buck	*Tragelaphus scriptus*
Eland	*Taurotragus oryx*
Buffalo	*Syncerus caffer*
Sable antelope	*Hippotragus niger*
Kongoni	*Alcelaphus buselaphus (lichtensteinii)*

Rodents

Brown rat	*Rattus norvegicus*
Striped bush squirrel	*Paraxerus flavovittis*

Bats

Yellow-winged bat	*Lavia frons*
Singing fruit bat	*Epomops dobsoni*

Lagomorphs

Scrub hare	*Lepus saxatilis*

Other species

Ground pangolin	*Smutsia temminckii*
Aardvark	*Orycteropus afer*

Primates

Blue monkey	*Ceropithecus mitis*
Vervet monkey	*Cercopithecus pygerythrus*
Olive baboon	*Papio anubis*
Yellow baboon	*Papio cynocephalus*
Garnett's Galago	*Otolemur garnetti*
Mozambique Galago	*Galagoides granti*

Section 4
Crocodile Survey

Clockwise from top: 1) Typical crocodile habitat, a slow-flowing section of the river with low banks and an abundance of prey – here Egyptian Geese and Puku. 2) Motorboat used to carry out night-time spotlight surveys. Crocodiles rest on the banks until the air cools at around 9pm. 3) Fishermen come into conflict with crocodiles directly through attacks by larger individuals and through poaching.

Section 4: Crocodile survey

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Participants: Malcolm Starkey, Mr Benson Neil Birnie, Ladislaus Kahana, James Maynard, Mluta T. Mluta, Ephraim Mwangomo, Mr Ngalapa, Nyingi Johnson, Hugo Rainey, Will Robinson.
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Introduction

The Kilombero Valley contains large numbers of Nile crocodiles *Crocodylus niloticus*. A cropping scheme was carried out between 1988 and 1989, and there have been repeated suggestions that a proportion of the crocodiles on Tanazania's quota for crocodiles could continue to be taken from the valley. If this is to be the case, monitoring of crocodile populations is necessary to determine whether cropping levels are sustainable. Sustainable cropping also requires knowledge of the distribution of the crocodile population, so that cropping effort can be targeted. This survey aimed to contribute towards initiating an effective monitoring programme.

Previous work

As a result of the plans to crop crocodiles in Kilombero Valley in the late 1980's a brief aerial survey was carried out by Ian Games in 1988 to try to establish baseline data for monitoring. However only a small proportion of the valley was surveyed and they found that aerial surveys were very difficult due to 1) the difficulty of following a single river channel with many twists and turns, 2) the fact that there are many ox-bow lakes and marshes with dense vegetation that contain crocodiles. Their survey saw 16 crocodiles in 30 minutes of flying time in the 'lower Kilombero marsh', which corresponds to the area from the Kivukoni ferry up to where the channels start to divide, and they saw 180 crocodiles in 30 minutes in the 'upper Kilombero marsh' where they attempted to follow the Mnyera River channel. However, they found that the number of meanders in the river made it impossible to calculate the length of river surveyed and they were therefore unable to estimate densities.

If cropping is to continue in the Kilombero Valley, monitoring of crocodile populations is necessary to determine whether cropping levels are sustainable. Sustainable cropping also requires knowledge of the distribution of the crocodile population, so that cropping effort can be targeted. Although aerial counting is usually regarded as the cheapest and quickest way of carrying out crocodile surveys, the difficulties inherent in surveying a swamp area with many meandering rivers considerably reduce its potential in areas such as the Kilombero Valley. In this study, we had already planned to use a motorboat to carry out waterbird counts so the marginal cost of carrying out a boat-based survey of crocodiles was low. We were able to conduct waterbird counts during the day, and crocodile counts at night.

Methods

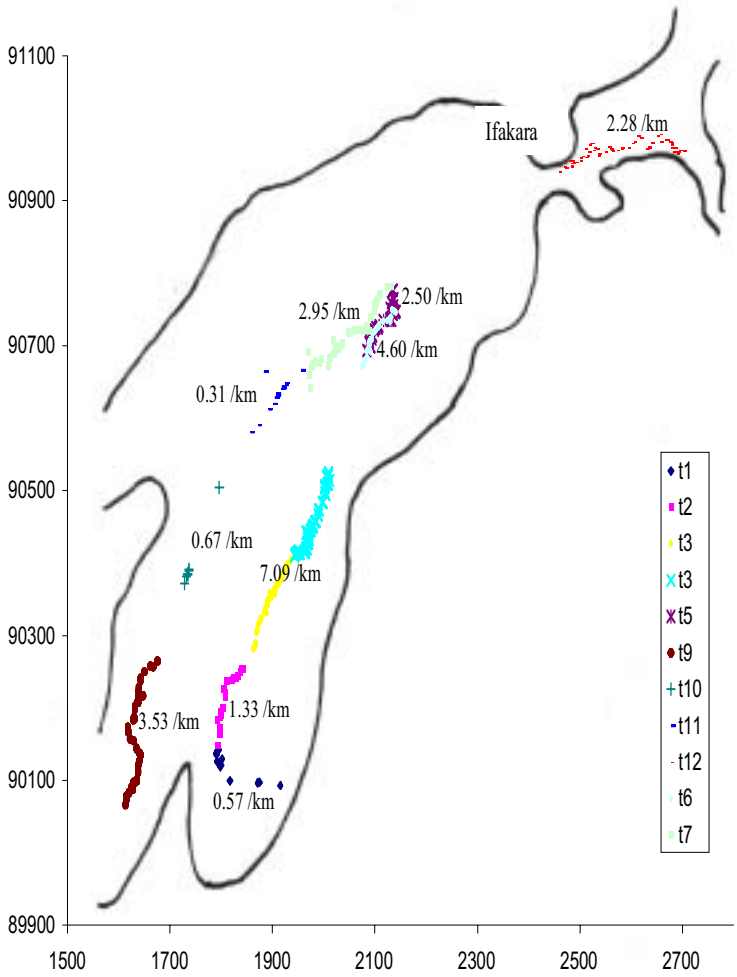
Crocodile counting was carried out using standard procedures. Counts started when it was fully dark and when the air temperature was lower than the water temperature (measured with a simple thermometer). We moved slowly along the river, scanning the water and banks ahead with a spotlight. Crocodiles were identified by eyeshine. The position of each sighting and the distance travelled along the river was recorded using a GPS.

Two types of boat were used. On the larger and deeper river channels, an aluminium boat with a 25hp outboard motor borrowed from the Selous Game Reserve was used. Breakdowns were frequent and any future surveyors should ensure that they are well equiped with spare parts, including a fuel line and spark plugs. We are grateful to BP Tanzania for providing the fuel for this survey. On shallow and narrow rivers a flat-bottomed fibreglass canoe was used. This was highly effective, since it had a low draft and could easily be pushed across sandbanks. However, it was also very dangerous due to the presence of numerous hippo in the smaller river channels, even late at night. One particular encounter with a wounded hippo in a very narrow section of river was a close call. For this reason, we do not recommend that canoes are used for any future survey, and that monitoring is restricted to the wider river channels where a larger boat can be used.

Using both boats a total of 247 km of river channels (see Map 1) was surveyed.

Results

A total of 684 crocodiles were seen over the 247 km of river channel surveyed. This corresponds to an overall density of 2.77 crocodile seen per km. However, the density of crocodiles seen on each section of river varied considerably. The number of crocodiles seen on each section of river is given in Table 1 on the following page, see the map below for the location of each section of river. The observed density of crocodiles ranges from virtually zero on parts of the Mpanga river, to about 7.1/km on the lower Furua river. Some of the crocodiles seen were very large. Safari hunters report regularly taking crocodiles that are 14-15 feet long. We saw one crocodile that had been shot and measured as 14.5ft, and the next day saw a live crocodile that was obviously considerably larger.



Map 1. The floodplain of the Kilombero Valley with stretches of the river surveyed marked. Transect numbers are shown in the legend and the average density of crocodiles seen on that transect is displayed on the map.

	Details	Notes	Start location	End location	Total distance travelled	Number seen	Density (n/km)
1	Upper Furua River 1	Broad river, often 25-40m, mostly very shallow. Canoe.	0191583, 9009301	0179466, 9014868	19.3	11	0.57
2	Upper Furua River 2: Ngota to Lupemenda	Deeper, narrow (5-12m wide), lots of overhanging phragmites, one portage necessary, lots of hippos. Canoe.	01795, 90149	01863, 90281	16.6	22	1.33
3	Lower Furua 1: from Lupemenda	Narrow, many sandbanks. Many hippo and other animals seen. Several hunting camps. Canoe.	01863, 90281	01944, 90409	17.9	127	7.09
4	Lower Furua 2: to ford by safari hunters camp	As above.	01944, 90409	02010, 90524	16.0	114	7.13
5	Lower Furua 3: to confluence with main river	Canoe.	02084, 90693	02135, 90776	16.0	40	2.50
6	Kilombero River 1	Wide river, deep, many fishing camps. Few hippos seen. Motorboat.	0207530, 9067075	02134, 90749	13.9	64	4.60
7	Kilombero River 2	Wide river, deep, many fishing camps. Few hippos seen. Motorboat.	020973, 90659	02132, 90781	23.4	69	2.95
8	Mpanga River 1	Forested banks, no sandbanks, many fallen trees obsructing river. Canoe. Count abandoned after 6km.	01810021, 9010739	018127, 90101	6.0	0	0.00
9	Mpanga River 2	Deep, fast flowing. Canoe.	018214, 90066	018273, 90264	30.3	107	3.53
10	Mpanga River 3	Deep, fast flowing. Confluence with Kihansi River at 01918, 90643. Canoe.	01858, 90580	01956, 90666	19.5	13	0.67
11	Mpanga River 4	Deep, Fast flowing. Canoe. All sightings in first 3km.	0172874, 9037058	01797, 90504	19.1	6	0.31
12	Kivukoni Ferry to Boma Ulanga	Wide river, extensive human presence on banks	0245954, 9094022	02702, 90968	48.6	111	2.28
	Overall				**246.6**	**684**	**2.77**

During night counts, not all crocodiles are seen, since some may be submerged, so the 'real' density of crocodiles is likely to be higher than that we observed. Previous studies have estimated night-count correction factors of between 1.7 and 3.0 depending on location and various other factors such as river width, water temperature cloud/moon cover during the count. However, we feel that applying correction factors derived from other locations is not appropriate. Nor is it appropriate to try to estimate the total population of crocodiles from our data, since there are an unknown number of river channels that were not surveyed, and there are also probably many crocodiles in swamps and lakes that would not be recorded by this study.
Many more crocodiles were seen on smaller rivers, where there are fewer people than were seen on the main channels, even where there was suitable habitat. However, crocodiles were also seen in considerable numbers even in some areas of high human presence. In some areas where there were few people there were also few crocodiles, probably due to a lack of suitable habitat. River ecology, rather than human distribution, would seem to be the major factor determining the distribution of crocodiles in the Kilombero Valley.
Crocodiles are widely feared, by both fishermen and people who have to cross rivers where there are no bridges or who have to wash in river channels. Most people were able to tell stories of people who had been killed by crocodiles. However, it would appear that there is little targeted hunting for crocodiles, since their meat is reportedly not eaten. A dead crocodile was seen floating down the river; it had probably been caught in a fishing trap or net.
The main value of our survey is to provide a basis for future monitoring to assess changes in populations of crocodiles as a result of organised cropping or otherwise. The data could be used in one of two ways: 1) as a baseline set of counts that can be repeated at a future date or 2) as a basis for designing a more appropriate aerial survey. These two options are discussed below.

Repeating this survey

There seems to be scope for repeating sections of this survey, but the efficiency/utility of boat counts as a long term-monitoring technique is less clear. As discussed above, we do not recommend that canoes be used for repeat counts due to the danger inherent in this method of transport. Counts are therefore restricted to the larger rivers, unless they are carried out during the rainy season, when much of the valley is flooded. However, at this time of year crocodiles are unlikely to be concentrated in the rivers, and counts are likely to be highly sensitive to the level of flooding.
There are many channels which are navigable by motorboat, many of which we did not cover in this survey. During waterbird counts we also travelled along channel towards Kihansi and to Mofu in the motorboat, but the number of obstacles (logs, weed etc) and the narrowness of the channels in places means that it would probably be impractical to survey these at night. If channels were mapped in more detail, a considerable length of river would be navigable. However, not all navigable channels currently contain many crocodiles – some, such as the area nearest to Kivukoni ferry presumably do not since there is a high human population density, and others such as the channel leading to the Kihansi River, do not, presumably due to ecological factors (lack of sandbanks or the fact that crocodiles are not visible in some areas).
Thus, in practice motorboat surveys are probably limited only to some of the wider channels. These are also the areas where there are many people, but probably also where the bulk of any cropping would take place since this is where access is easiest. Thus, while motorboat night counts could probably be effective in monitoring the areas where crocodiles are cropped, they would not be able to provide more general information about the status of crocodile populations in the valley as a whole.

Designing more systematic aerial counts

Aerial surveys have the advantage that they can cover a large area in a short time, and can follow even shallow channels. Their speed means that they usually end up being cheaper than boat-based surveys. However, as Games (1988, pers. comm.) found, using aerial counts to survey crocodile populations in the Kilombero Valley is very difficult due to the multitude of channels, which split and rejoin and meander greatly. This survey does not suggest any easy remedies to this problem. In fact, by showing that crocodile densities vary considerably within the valley, they suggest that designing effective aerial surveys is likely to be even more difficult. We therefore suggest that despite their limitations, boat-based counts are likely to be the most effective method of monitoring crocodile distribution and abundance in the Kilombero Valley.

Conclusion

Crocodiles are abundant in the Kilombero Valley and are probably not currently threatened. River ecology rather than human distribution is probably the main factor determining crocodile distribution in the valley. This is the first study that has attempted to assess crocodile distribution and abundance in any detail and as such provides a basis for future monitoring. There is certainly scope for cropping, but monitoring crocodile densities is difficult. Repeated counts using motorboats are probably the only way to get reasonably detailed data for monitoring. This would be time-consuming and therefore probably expensive. Costs could be reduced if crocodile counts were combined with a waterbird survey, as in this study.

Section 5
Social survey

Clockwise from top: 1) A focus group with Sukuma pastoralists near Itete during the social survey. 2) Huts in a rice field used for protecting fields against crop raiding. Damage by wild animals is one of the greatest agricultural problems in the valley and imposes large direct and indirect costs on farmers. In the year of the study, much rice had not been harvested because of the drought. 3) Crossing the Mofu river by canoe. There are several villages in the valley which are accessible only by canoe since bridges have collapsed. Shallow rivers are often forded, but several people and many cattle are killed by crocodiles each year.

Section 5: Social survey

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Part 1: Introduction and aims of the social survey

People and conservation

Conservation is about people. Although the end goal of conservation may be to maintain populations of particular species or the functioning of biological systems, it is the activities of people that affect wildlife, and conservation is the process of controlling those activities that are deemed threatening. In traditional conservation thinking, dating from the colonial era, it has been regarded as impossible for people and wildlife to co-exist over the long term, and conservation has therefore been focused on enforcing separation of wildlife and people in national parks and game reserves. However, recent conservation thinking in Tanzania and elsewhere emphasises the need to take local people into account when designing conservation management strategies. In this paradigm of the 'new conservation', people are seen as potential partners in conservation strategies, rather than always as 'the enemy'. Supported by studies which show that given the right social and economic conditions people can coexist with high densities of wildlife, 'community-based' conservation schemes have proliferated, and community involvement is now the norm for new conservation schemes. These schemes are based on the premise that if people living in or near conservation areas receive sufficient benefits from wildlife then they will have an incentive to refrain from practices threatening to wildlife, and will be motivated to defend 'their' resources from outsiders who attempt to exploit them. The benefits from wildlife can be in the form of wildlife-funded development projects, cash revenues and/or meat and other products from wild animals.

In the Kilombero Valley, the large numbers of people living in the area, highly dependent on the natural resources of the valley, probably make exclusionary conservation in the traditional sense politically and practically impossible. A 'community-based' scheme is therefore on the face of it a highly attractive option for conservation in the Kilombero Valley. Indeed the proposal by the WWF in 1992 for a major conservation scheme in the valley was based on a 'community wildlife management' model, and current thinking by development agencies in the field is leaning towards this view. However, experience from conservation schemes in other African countries and beyond indicate that 'community-based' conservation is only likely to be successful under certain relatively well-defined conditions, and often only for certain well-defined goals.

A key lesson from previous 'community' conservation programmes has been that it is necessary to take into account the social and economic factors that structure people's interactions with wildlife, and in particular to take account of variation and heterogeneity in what might otherwise appear relatively homogenous communities. In the case of the Kilombero Valley, there is relatively little socio-economic information available, and no recent quantitative information. Given the paramount importance of taking account of local socio-economic realities, this project therefore included a social survey with the aim of achieving a better understanding of the socio-economic context of conservation in the Kilombero Valley. This section of the report presents the socio-economic data collected on subjects including people's livelihood strategies, peoples' interactions with wildlife and attitudes towards conservation. After the data is presented, a discussion relates this to experiences from other conservation programmes, and analyses the possibilities for community-based conservation along the lines of other programmes in Tanzania. A final conclusion and discussion summarises the findings from each section of this project and makes some tentative suggestions as to possible future conservation directions.

Part 2: Methodology and study sites

Given the limited duration and personnel of this project, it was necessary to limit the study to certain well-defined objectives. After a preliminary survey, it was decided that as with the biological surveys, it was impractical to work on both sides of the valley. The survey was therefore restricted to Ulanga District, on the southern side of the valley. As described in the background to the valley, earlier in this report, three main livelihood strategies were identified: farming, fishing and pastoralism. It was decided that in was impractical to study the social aspects of the fisheries of the valley in sufficient detail in this project, and since fisheries were the subject of a proposed study by the District Natural Resources Office we decided to focus on farmers (some of whom also fished) and pastoralists.

The aim of the survey was to investigate the socio-economic context for conservation, and in particular to evaluate the potential for community-based conservation so the main research questions were:

- What are the main livelihood strategies practiced in the villages?
- What variations are there in these livelihood strategies within and between communities in the valley?
- What are the main ways that people interact with wildlife?
- What are people's attitudes towards conservation, and how might they react to the provision of wildlife-derived benefits from a community-based conservation programme?

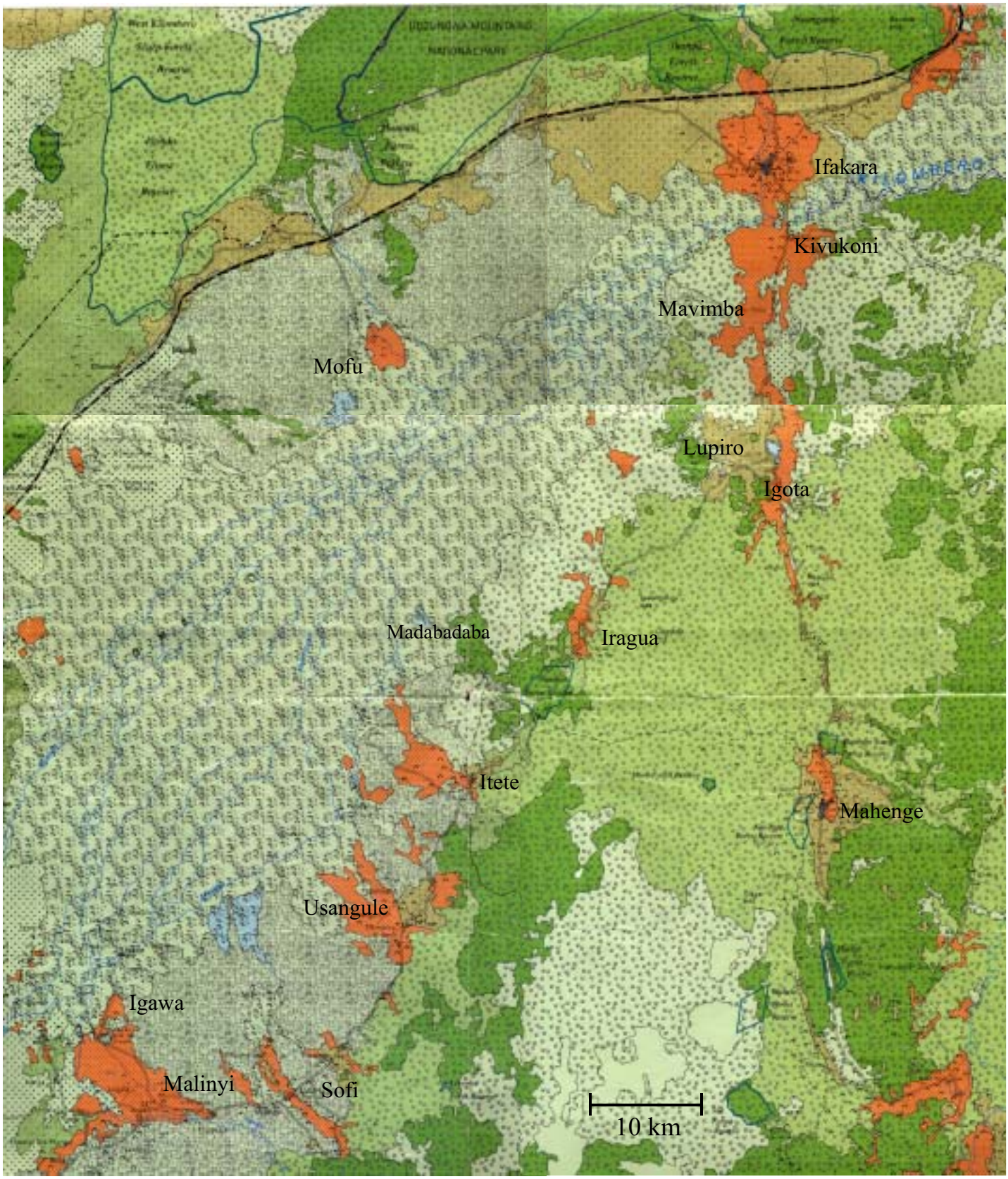
To address these questions both quantitative and qualitative methods were used to collect data on differences in livelihood strategies, wealth and political influence, especially as they related to interactions with wildlife. These included:

- A questionnaire survey/ semi-structured interviews
- Group discussions
- Discussions/informal interviews with project officers, district and village officials
- Use of secondary sources - documents and literature.

The methods used were modified from those of Gillingham (1996, 1998), who studied the social context of conservation around the nearby Selous Game Reserve. The following section describes the methodology used in more detail.

Choice of study sites

Given the limitations in terms of time and personnel and the difficulty in travelling from one side of the valley to the other, the survey was limited to the southern half of the valley, in Ulanga District. Five study villages were chosen out of a total of 11 established settlements in or bordering the floodplain. The villages chosen spanned the length of the valley and were chosen to represent the diversity of communities in the area. The villages chosen were: Lupiro, Iragua, Itete, Usangule and Igawa (see Map 1 overleaf).



Map showing villages and study sites here

Questionnaire survey

A questionnaire survey was carried out in each of the five study villages in Ulanga District. The questionnaire is shown in Appendix 1. The questionnaire was designed in four sections, with a variety of fixed-format and open-ended questions:

1) basic socio-economic information, schooling, household composition, tribal affiliation etc

2) income sources and indicators of wealth

3) agriculture and livestock

4) attitudes to wildlife and conservation

The questions were translated into Swahili, and the fieldwork was carried out by three Tanzanian field assistants – Johnson Nyingi, an experienced PRA facilitator, Joachim Makoti, a member of the District Natural Resources Department and Lydia Kappa, a graduate from the University of Dar-es-Salaam. Each questionnaire took approximately 45 minutes, and was followed by a period of semi-structured discussion, in which the respondent was encouraged to ask questions of the interviewer as well as vice-versa. Women respondents were usually interviewed by one of the female members of the project.

Sample size and respondent selection

The household, defined as 'a group of persons who live together and share expenses', was used as the sampling unit for this survey. The number of households was estimated based on the number recorded in the 1988 census, with a correction factor of 2.9% per year (the long term growth rate) applied to compensate for the age of the data. The number of households to be sampled was calculated based on a 7–10% sampling intensity (Oppenheim 1992). Within each household one member was selected for interview, this was usually the household head. In total 229 respondents were interviewed (Table 1), of which 55 (24%) were women. Since most of the questions in the questionnaire were factual (eg on possessions owned), the gender imbalance was probably not a significant problem and has probably not biased the results to a great extent[1]. In a longer, more detailed study, it would be preferable to carry out more qualitative study, including separate gender-sensitive interviews with both men and women to ensure that women's opinions were represented equally.

Table 1: Number of households in the study villages and sampling intensity

		Number of households			
Village	**Population in 1988[1]**	**1988[1]**	**1997 (est)**	**Number of questionnaires**	**Sampling intensity (%)**
Lupiro	3,706	585	756	50	6.6
Iragua	1,850	331	428	41	9.6
Itete	4,425	572	739	40	5.4
Usangule	2,430	383	495	42	8.5
Igawa	3,027	483	624	56	9.0

1) Data from the District Council, based on the 1988 census

Although Tanzanian villages have a fairly strong organisational structure, no lists of households were available with which to make a random selection, and it was not practical to create them within the time available for this survey. Instead, a list of the ten-cells (administrative groupings of 10–30 households) within

[1] An exception is probably some of the questions on agriculture. Since a distinction between women's 'kitchen gardens' and fields of staple crops was not made explicit in the questionnaire, it is likely that many men did not mention crops grown by their wives, such as melons, egg plant and other vegetables. As a result, data from several questions that may have been influenced by this have not been included here.

the village was compiled and several of these were selected randomly for sampling. Within the selected ten-cells, households were selected for interview either randomly or haphazardly. In addition, a number of questionnaires were carried out opportunistically. Thus the sampling protocol was not strictly random and bias could have been introduced if, for example, richer households near the centre of the village were interviewed preferentially.

Pastoralist questionnaires

Questionnaries were also carried out among the pastoralist community. The bulk of the questions were the same, but several were modified and some added to reflect the different interests and lifestyle of pastoralists (see Appendix 1). Due to the scattered nature of the pastoralist bomas, their inaccessibility and the lack of official records on their number and location, it was impossible to obtain or derive a sampling frame with which to select a representative sample. Instead, connections with a Maasai headman were used: he offered to use his influence to call a meeting of representatives from as many pastoralist households[2] as possible. In this way, representatives (in most cases the head of household) from 21 households were gathered together. This opportunity was used to have a group discussion, and to interview the attendees. A separate group discussion was held with members of several Sukuma households near Itete.

This method obviously had several disadvantages, most especially in the potential bias in attendees: people living further away were probably less likely to attend, as well as poorer households who could not spare the time to send a representative and people who might have had disagreements with the Maasai calling the meeting. However, given the short duration of the study, it was probably the best that could be hoped for. The attendees represented a significant proportion of the pastoralist households with bomas within the Ulanga side of the Game Controlled Area. Rough estimates based on informal observations suggest that they represented at least 10% and possibly up to 40% of bomas. Although summary statistics have been calculated from some of the data collected it should be emphasised that they apply only to the households sampled and are not necessarily representative of the pastoralist community as a whole.

Sources of bias

Other than the sampling bias discussed in each section above, bias and inaccuracy may have been introduced in the carrying out of the interviews and in the data analysis. A particular concern is the effects of respondents' perceptions of the interviewers. One of the interviewers, although a local of the area, was a member of the District Council, the other two were not from the valley. All three were financially rich in relation to most of the respondents (they were paid significantly more per day than many households in the valley were earning in a week). In addition, other members of the team (who did not participate in this survey, but were nevertheless associated with it), included game scouts and other 'officials', which is likely to have affected the respondents perceptions of the interviewers and hence the responses they gave. This is most likely to have affected the responses to subjective questions concerning hunting and conservation rather than the more objective questions; where bias is suspected, it is discussed along with the analysis of the responses.

Group discussions

In each of the five study villages, two focus group discussions were carried out, one each with a male and female group. In addition, one discussion was held with a group of Sukuma pastoralists, one was held with a group of Maasai pastoralists, and one with a large mixed group of pastoralists, to make a total of 13 discussions. Several other informal discussions were held in bars and at fishing camps.

The number of attendees varied from 9 to 18. Discussions were held in Swahili (with group members providing impromptu translation in other languages, eg Sukuma) where necessary. The discussions were facilitated by Johnson Nyingi, a Tanzanian with extensive experience of PRA techniques. The female

[2] Household structure and kin relations in pastoralist societies are often complex. For the nature of this survey it was not necessary to delve deeply into the complexities of intra-household relations, and the "household" was used as the functional unit for the study. Those wishing to find out more about the structure of pastoralist households are advised to consult Homewood and Rodgers (1991) for Maasai, Lane (1998) for Barabaig and Charnley (1998) for Sukuma, as entry points into the literature.

discussions were facilitated by Lydia Kappa, a graduate from the University of Dar-es-Salaam. Notes were taken during the discussions, and they were also recorded on a portable cassette player, and the full discussion later transcribed and translated by Nyingi. Feedback on the discussions, including a summary of what had been said, was prepared (in Swahili) and presented to the villages as soon as practical after the discussions were held.

It is likely that considerable bias arose in the composition of the groups – depending on the time they were held some people may not have been able to attend, others may have been prevented from attending, others may have been too poor, or too shy to attend. This was in part a result of the necessity to organise the discussions in a short time and through local officials, which meant that there was little chance to decide the composition of the group. It would certainly have been useful to hold more discussions with different groups of people, but this was not possible for several reasons:

- researchers time – due to the emphasis on collecting quantitative information as well (see Critique of Methods section below);
- participants time – it was sometimes difficult to get people to gather for the discussions, a one hour discussion could sometimes take all afternoon, even when it had been arranged previously;
- respondent fatigue – the study coincided with a PRA facilitation exercise carried out by the District Council/Irish Aid, which meant that many people had already spent much time in discussions.

However, the discussions that were held provided a significant amount of useful information on the general issues and concerns of the participants.

Assessing material well-being

To create an index of material well-being, respondents were asked which 'consumer goods' their household possessed (bicycle, radio, torch etc), about the number of livestock, smallstock and poultry owned, and about the construction of their house (thatched or corrugated roof, mud or brick walls etc). From this information a 'possessions score' was calculated, based on scores given for ownership of different items in relation to their approximate cash value (Table 2). The scores used were based on those used in previous studies in Tanzania by Sender and Smith (1992) and Gillingham (1998).

Table 2: Scores used to calculate the 'wealth index'

Items	Score
House structural features	
Metal roof, non-mud walls or cement floor (each)	3
Consumer goods	
Bicycle (each)	3
Radio	2
Kerosene lamp, kerosene/charcoal stove, torch, watch (each)	1
Livestock	
Cows, >3 smallstock or >40 chickens	3
1–3 smallstock, >5 to 40 chickens	2
1–5 chickens	1

A wealth index was used because it relied on responses to fixed questions, rather than on respondents estimations of cash income, which are notoriously prone to under-reporting or exaggeration, and the concept of which is not necessarily wholly applicable to subsistence households anyway (Sender and Smith 1992). The methodology used was based on that used in previous studies in Tanzania, in which the index was compared with detailed data on actual household incomes and found to be a useful index (Sender and Smith 1992). In this case the ability to make comparisons is particularly useful since a study by Gillingham (1998) used this

methodology to study a community-based conservation scheme with a management structure very similar to one being proposed for the Kilombero Valley.[3]

Data analysis

Ranking questions

For several topics, it was not possible to collect accurate quantitative data as to the relative importance of different factors, for example crop damage and diseases for agriculture. In these cases people were asked to rank the various factors in order of importance. For these data sets weighted-rank indices were calculated for each factor so that the relative importance of each factor could be compared between different subsets of the respondents. The responses were weighted using the reciprocal of their rank so that a rank 1 was scored 1, a rank 2 was scored 1/2, a rank three was scored 1/3 and so on. If a factor was not mentioned it was scored zero. The weighted rank index was then calculated as the mean weighted rank for all respondents in the subset of the data being analysed.

Critique of the methods used

Questionnaire surveys have been criticised because they are too extractive, they require a large amount of survey effort, a large amount of time spent on data entry and analysis, to produce results that may well reflect the preconceptions of the questionnaire designer rather than the real opinions and concerns of the respondents (eg IIED 1997). The experience of this survey bears out many of these criticisms: the survey produced a huge amount of data that required a considerable investment in time to order, enter into a computer and analyse, and as a result has only now been analysed, 18 months after it was collected[4]. Given that it has only been analysed now, it has been impossible to remedy some of the questionnaire's shortcomings, or to follow-up many of the interesting issues raised. In contrast, the information from the focus group discussions, transect walks and so on was analysed swiftly and in situ, allowing summaries of the discussions to be returned to the villages soon after they were conducted, and, in some cases, for further discussions to be held to follow-up the points raised.

However, during the focus group discussions, it was evident that the discussions were each dominated by one or a few people, and that the opinions of women and younger people in particular were marginalised. This shortcoming was only partly overcome by holding separate women-only discussions, as younger women were marginalised (either actively or passively or both). As a result many of the 'discussions' in fact turned into question-and-answer sessions with one or a few people, in the presence of a more-or-less interested audience. As well as difficulties in getting people within the group to talk, local protocols meant that it was difficult to determine the composition of the group except at the most general level. In contrast, the questionnaire/interviews allowed individuals to express their opinions without the pressure of conforming to the views of others in the group, for example women and young males. Thus, the two methods complemented each other and have provided more information than would have been the case if only one had been used.

[3] Recently, assessments of wealth have been based on a much more 'participatory' approach, in which the index used for measuring wealth is derived from discussions with the respondents themselves, rather than determined *a priori* by the researcher (eg IIED 1997). The rationale behind these participatory methods is that the researcher's perception of 'wealth' may be very different from that of the respondents – in particular people often consider more intangible factors such as location of houses as more important as owning particular items. Indeed, part way through this study, one of the field assistants complained that we should also be recording possession of other items such as chairs, tables and plastic buckets as they were at least as important as those included in the index. In a repeat study a more participatory method should certainly be used as well, though it should be recognised that these are also prone to bias.

[4] However, the data could certainly have been analysed much more quickly. Any future project should allow sufficient time for such data to be analysed in the field (or at least in the country), before any expatriate researchers leave the site. This was a considerable error of judgment on our part, and although other factors have compounded the problem, contributed to the late production of this report.

Part 3: People of the valley and their livelihood strategies

Introduction

There are two main livelihood strategies used by people in the Kilombero Valley: farming and pastoralism. Very few farmers kept cattle or small stock, but most pastoralists also grow crops. This section presents basic socio-economic information on both groups, including village composition and livelihood strategies.

Agriculturalists

Ethnic composition of the villages

Figure 1 shows the ethnic affiliations of respondents from each village surveyed. The differences between villages were statistically significant (χ^2 test, χ^2=231, DF=16, P<0.001). Igawa, a floodplain village, differed from the other villages in that it was dominated by Ndamba, or "people of the river", who traditionally depend to a large extent on fishing for their livelihoods (Jatzhold and Baum 1968, WWF 1992). The community composition of Igawa was much more uniform than that of the other villages, a large majority of the population being Ndamba, and with only three other ethnic groups represented. Lupiro had the highest proportion of Ngindo people (37%), roughly equal to the proportion of Pogoro. The high proportion of Ngindo at the eastern end of the valley is a result of 'concentrations' in an attempt to combat sleeping sickness under German rule: between 1940 and 1943, the inhabitants of *miombo* woodland in what is now the Selous Game Reserve were re-settled in clearly-defined areas which were cleared to eradicate the habitat of the tse-tse fly (Jatzhold and Baum 1968).

Lupiro also had the highest ethnic diversity of any of the villages, with 9 different ethnic groups being represented. The remaining three villages were dominated by Pogoro, a tribe closely related to the Ndamba[5], but who historically have been less dependent on fishing for their livelihoods, and more dependent on farming maize on the uplands (Jatzhold and Baum 1968). In both Iragua and Itete there were a significant proportion of Ngoni (27% and 17% respectively).

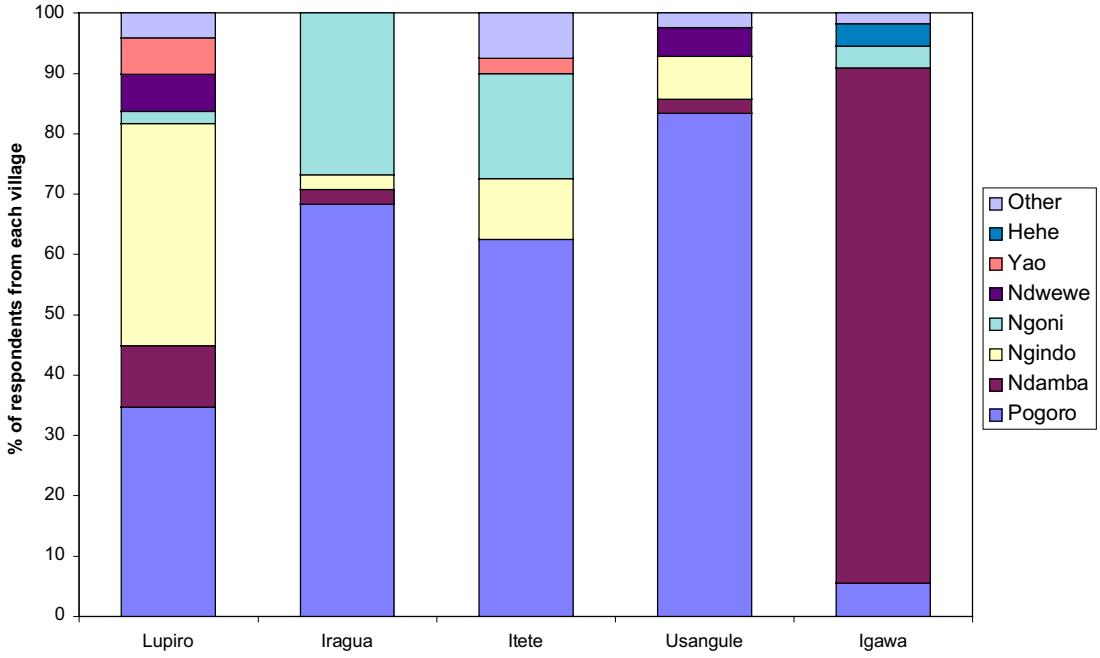


Figure 1: Ethinc composition of the study villages

[5] Jtazhold and Baum (1968, p35) say "The old people state that the Pogoro and Ndamba formerly lived as one tribe in the region of the upper Luhombero before they immigrated into the Kilombero Valley under pressure from the south."

Immigration and origins

To assess the amount of immigration into the valley, people were asked how long they had lived in the area, and where they had moved from. Twenty-five respondents (11%, N=228) said that their family had become established in the area since their grandparents generation (ie their parents had moved to the area). Of these 9 were Ngoni whose parents had moved from the Songea area (south of the Selous) between the mid-1940's and the mid-1960's and 5 respondents were Ngindo who had moved from the Lindi area (to which they had moved due to formation of the Selous Game Reserve) between 1950 and 1965.

However, only eight households (3.5%), from a variety of ethnic backgrounds, were headed by first-generation immigrants. Of these, three had moved from Kilombero District since the mid-1980's and one each had moved from Songea, Mbeya, Singida, Lindi and Iringa Regions. Three households had moved into the area because one member was a professional seeking work: one head teacher, one tailor and one carpenter. Other reasons for moving included marriage, treatment by traditional healers and other kinship ties. Land availability and farming were not mentioned as reasons for immigration. Recent immigrants, who tended to be from minority ethnic groups, were less likely to rank crop surpluses as their most important source of income. The weighted rank index for crop surpluses for this group was 0.67 as compared to 0.90 for other all other ethnic groups. They were more likely to rank business income as important (wri=0.25 vs 0.12 for all other ethnic groups). This supports the finding that many immigrants to the villages did not come in search of land, but came because of business and employment opportunities.

Since respondents were not always able to say exactly when their family moved to the area and since the sample size is small, it is difficult to calculate the overall immigration rate. A further complication is that recent immigrants are likely to live on the margins of a village, and so these households may have been underrepresented in this survey. However, a rough estimation implies that the rate over the previous ten years has been between 1 and 3 households per village per year.[6] The number of recent immigrants was higher at the north-eastern end of the valley, and especially in Lupiro (which is sited at a road junction, and is close to Ifakara, the main town and thus the most accessible), but sample sizes were too low to analyse this in detail.

Income sources

Respondents were asked to rank their sources of cash income in order of importance, the results for the whole sample are shown in Figure 2.

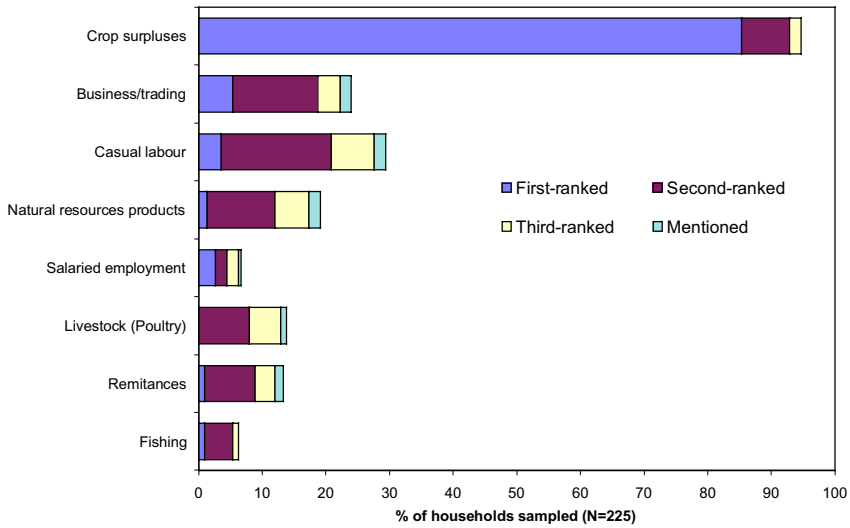


Figure 2: Households' sources of cash income ranked by importance

[6] Emmigration was not studied, so it is not possible to estimate the net rate of movement of people. However, 13% of respondents mentioned that remitances from family members living in towns were an important part of their income, suggesting that a significant number of people may leave the area, at least on a temporary basis.

The overall sample shows that for the vast majority of households, crop surpluses (mostly of rice) are the major source of cash income[7]. Other important sources of income mentioned were casual labour, trading and the sale of products from natural resources, mostly local-brew and mats woven from palm fronds (*Phoenix reclinata*). Making local-brew and mat weaving were mostly done by women, whilst casual labour mostly involved men, but the reported importance of different livelihood strategies did not vary in relation to the sex of the head of household.

Casual labour was ranked more important in Lupiro (0.25 vs 0.10 for the other villages), which may have been due to the proximity of the Kilombero Valley Teak Company's plantation. Fishing was ranked higher in Igawa, but for the reasons discussed above, the sample size was not large enough for this finding to be significant. Otherwise, the importance attached to different livelihood strategies did not vary substantially between villages.

Table 3: Weighted rank index for different income sources by village

	Agriculture	Business	Casual labour	Natural resources products	Salary	Livestock	Remitances	Fishing
Lupiro	0.82	0.19	0.25	0.06	0.08	0.02	0.08	0.02
Iragua	0.88	0.18	0.09	0.14	0.03	0.05	0.05	0.02
Itete	0.96	0.09	0.06	0.07	0.08	0.08	0.08	0.02
Usangule	0.90	0.08	0.12	0.09	0.00	0.08	0.05	0.02
Igawa	0.87	0.12	0.18	0.08	0.02	0.06	0.05	0.07

Thus, the overall picture is one of homogeneity, with most people depending on the same crop surpluses for their livelihoods. However, such general measures mask considerable differentiation in standards of well-being; this is addressed in the next section.

Differentiation by wealth

Variation within villages

An index of material wealth was constructed for the settled agriculturalists as described in the methodology. From the results, it is clear that the majority of households experience extremely low standards of material well-being: the mean wealth score was 6.3, corresponding to a very low level of possession of consumer goods. The distribution of scores was highly right-skewed with many households having low scores, and few having high scores, as shown in Figure 3. More than 25% of households had a score of two or less. The median score was 5, with a range of 29 and 95% of households with scores between 0 and 17. It should be noted that even many of the households that are relatively better off cannot be described as ‘rich’.

[7] Fishing was mentioned surprisingly rarely, given that the Kilombero Valley is the largest inland fishery in Tanzania. This is probably because fishing for sale rather than subsistence requires a licence, and the majority of people in the valley do not have licences. They were therefore unlikely to mention fishing as a livelihood option, especially as one of the interviewers was directly associated with authority, in the form of the District Council. In addition, the survey coincided with an operation by the government's Field Force Unit, a military anti-poaching squad that is widely feared by local people. A woman in Igawa expressed these fears during a group discussion:

"...recently there was the Field Force Unit, who came to beat people because they were using natural resources illegally, and no one was aware, even the village government didn't know, and a lot of people were injured because of having fish cooked in their cookers…".

The importance of fishing to people in the valley is shown by the frequency with which people ate fish, with a majority of households reporting that they ate fish more than once a week.

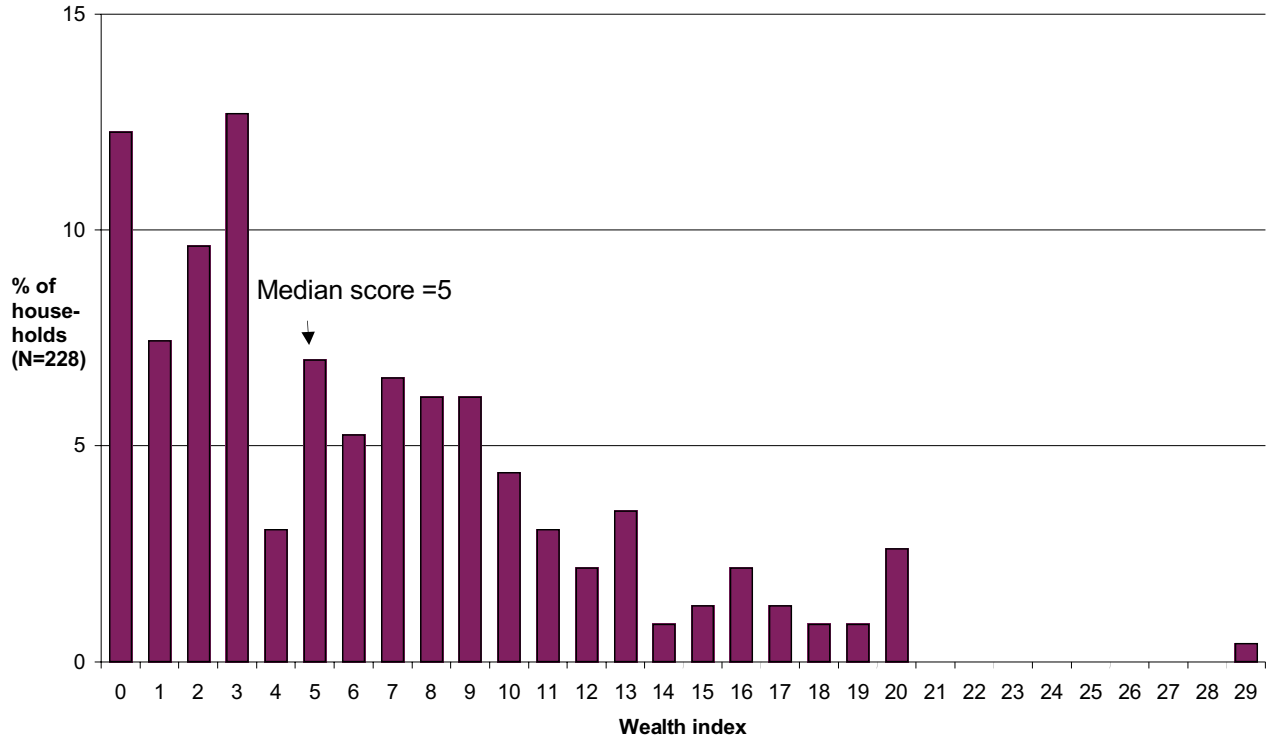


Figure 3: The distribution of wealth scores for the whole sample

Female-headed households had a significantly lower average possessions score (mean 4.5±0.8, median 3) than male-headed households (mean 6.6±0.4, median 6; Kruskal-Wallis test, H=6.22, DF=1, p=0.013). However, the range of scores for female-headed households was similar to that for male-headed households, so it would be a mistake to assume that all female-headed households were poor.

Wealth scores did not vary significantly between ethnic groups (Anova with log transformation, F=0.45, p=0.775).

Variation between villages

The same highly skewed distribution of wealth was found within each village. However, the average scores varied between villages. The difference was statistically significant, with Iragua and Itete having lower scores than the average for the whole sample and Lupiro and Usangule having higher scores (Table 4). The higher scores in Lupiro and Usangule are probably because both these villages have somewhat more substantial markets than the other villages, providing greater opportunities for trading and commerce. Lupiro, because of its key position at the junction of the roads to Ifakara, Mahenge (the District capital) and Malinyi, also has a substantially larger number of local restaurants, hotels and small shops than the other villages. In Usangule, the market also serves its twin village of Mtimbira, which is separated from it by only a short distance, and as such is a substantially larger trading centre than is found in the other villages.

Table 4 : Wealth scores by village

Village	Mean score	Median score
Lupiro	7.3	6
Iragua	4.6	3
Itete	5.7	3
Usangule	7.6	8
Igawa	6.2	6

Note: The differences between villages were significant: Anova with log transformation, F=3.80,DF=4, p=0.005

The basis of differentiation

Given that the majority of people ranked crop surpluses as their most important source of cash income, the differences in material wealth were based almost entirely on differences in land holdings. The distribution of area cultivated was highly skewed, with wealthier households cultivating significantly larger areas (GLM with log transformations, $F=37.7$, $p<0.001$). The poorest 25% of households cultivated an average of 1.2 hectares compared to 3.6 hectares for the wealthiest 25% and 4.6 hectares for the wealthiest 5% of households. Although land availability is starting to become a problem close to some villages ('infra-marginal land scarcity'), this appears to be a highly localised problem and land availability *per se* is unlikely to be a factor limiting the areas that each household cultivates. We therefore suggest that expansion of cropped area is currently unlikely to be a major threat for conservation at this moment in time. It was originally planned to compare the current area that is cropped with that 35 years ago using aerial photographs taken then as a guide, but unfortunately this was not possible in the limited time available. This would be a useful study and we hope that it can be carried out as part of a future project or by the District Council. To this end, the aerial photos we purchased have been given to the Ulanga District Council where they will be available to researchers.

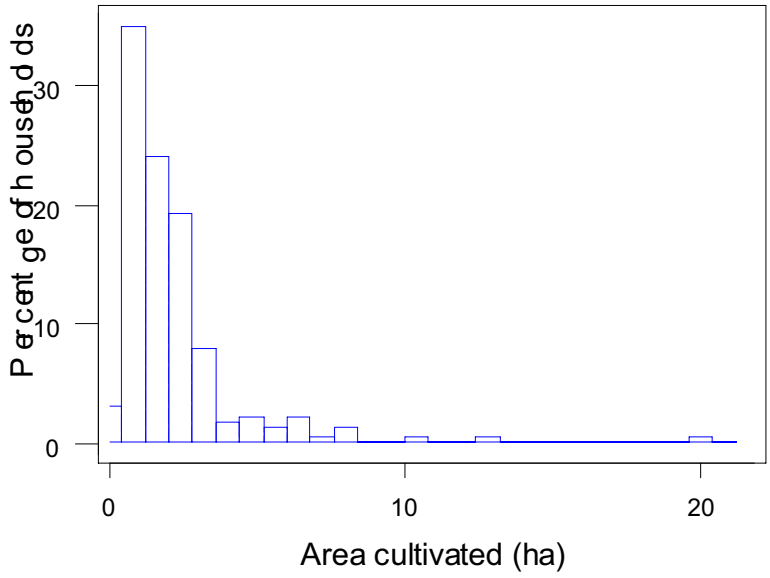


Figure 4: Histogram of area cultivated by each household

Hiring/selling labour

The differentiation in area cultivated as a result of household size has significant implications for the distribution of wealth. Households cultivating a larger area were able to employ other people to work on their fields. As a result, wealthier households cultivated a greater area per adult member (GLM with log transformations, $F=20.4$, $p<0.001$) and also cultivated more land per consumer (GLM with log transformations, $F=27.1$, $p<0.001$). This creates a significant division within the villages between those who worked on other people's land, and those who hired people to work for them. The majority of households (53%) worked for other people but did not employ external labour. A further 25% of households neither employed external labour or worked for anyone else, 4% both worked for other people and employed external labour, and 16% employed external labour but did not work for other people. Households employing external labour (whether or not they worked for other people) were significantly wealthier than those that did not (mean 9.5±0.9 vs 5.4±0.4, median

8 vs 4; Anova with log transformation, F=18.0 on 1 DF, p<0.001). Similarly, those working for other people had significantly lower wealth scores (mean 4.9±0.4 vs 8.2±0.6, median 3 vs 8; Anova with log transformation F=13.2 on 1DF, p<0.001).

Meeting household food needs

Only 16% of respondents (35, N=223, 5 no response) said that their fields had produced enough to provide for their family for the year. The year of the survey was a drought year, resulting in a seriously reduced yields that would have considerably reduced households abilities to provide for themselves. However, such droughts do occur relatively frequently, so this finding is not atypical. The main coping strategy of households who had not produced sufficient food to feed themselves was to work in other people's fields in exchange for food. Very few people were able to make up the deficit using cash income, since most people were dependent on the same crop surpluses for cash income. Those who had cultivated enough were significantly wealthier on average as measured by the possession score (mean 10.8±6.4 vs 5.5±4.8, median 10 vs 5; Anova with log transformation, F=16.5 on 1 DF, p<0.01).

Variation in food consumed

The number of times per week households ate any form of protein (fish, beans, meat, eggs) was significantly greater for wealthier households (GLM with log transformation, F=19.17, p<0.001). The poorest 25% of households reported eating protein only three times per week, compared to six times per week for the richest 25% and nearly daily for the richest 5%. The relationship held for each individual source of protein (p<0.02 in all cases). Few households mentioned eating wild meat, but this is not surprising as it is illegal. However, informal discussions indicated that people had a strong preference for wild meat, and wild meat (puku) was widely available in restaurants.

Pastoralists

There is no accurate estimate available of the number of pastoralist households in the Kilombero Valley, though the number of cattle has been 'guestimated' at 35,000 for the two districts combined. However, among the pastoralist population of the valley, immigration appears to be occurring at a high rate. Of the 21 households surveyed[8], all but six had moved into the Kilombero Valley in the last ten years[9] (ie 1987–1997), implying that pastoralist numbers had increased significantly during this period. This finding is supported by the data from focus group discussions with settled agriculturalists, where increasing crop damage by pastoralists' cattle was a major theme. For example, during a group discussion a woman from Itete[10] said that "*problems with pastoralists were few when they first came eight years ago* [ie in 1989]... *but now there are many problems.*" She continued: "*In 5 years to come they will finish the whole flood plain and they will be big farmers".* Informal discussions with a professional safari hunter who had worked in the valley for several years, travelling all over the interior of the floodplain, also supported this finding. The recent immigrants were from three major pastoralist groups: Sukuma, Maasai and Barabaig (also know derogatively as Mangati), and came from areas all over Tanzania, sometimes many hundreds of kilometres away. All the pastoralists had moved into the valley primarily in search of pasture for their cattle, however, the secondary reasons included: good land for crops (6/15), moving away from disease (3/15), land shortages and competition from other pastoralists (3/15) and conflicts with local farmers (1/15).

When asked whether the valley could support more cattle than there were at the time of the study, 6/21 said yes, while 10/21 said it could not, with the remainder unsure. However, all of them expected that more pastoralists would move into the area in the near future.

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[8] It should be stressed that the sample is not necessarily representative of all the pastoralists in the valley.

[9] Unfortunately one of the interviewers appears to have confused the question "How long have you had your boma at this site" and the question "How long have you lived in the Kilombero Valley", so it is impossible to say at what date each particular household moved into the area. However, it is certain that at least 15 (71%) of the respondents' households had moved into the valley for the first time in the last ten years. Since the total number of pastoralist bomas in the Kilombero Valley is not known, it is impossible to estimate an annual rate of immigration.

[10] Itete female focus group, held 20/8/97

Only four households (Maasai and Barabaig) mentioned that they practised transhumanance. These households brought their cattle to the valley to graze during the dry season, but kept them elsewhere during the wet season. They had only small dry-season farms of maize. The proportion of transhumanant pastoralists in the valley may be much greater than implied by this small sample, as the survey was carried out early in the dry season, and many pastoralists may have brought their cattle to the area later in the year.

The remainder of the households remained in the valley all year round and had farms that ranged from between 1 and 10 ha in size. Household sizes were considerably larger than for the agriculturalists. Only half the households said that they grew enough to feed their household for the year. Unlike agriculturalists, these households made up the deficit by purchasing food through cash raised from the sale of livestock. Moreover, it was not clear that the households that had not grown enough crops for their food needs had attempted to do so and suffered from agricultural problems, or had never intended to grow enough for their food needs. In terms of assets, pastoralists were substantially more wealthy than farmers, with even the poorest households owning 40 cows, worth a fortune compared to the assets of the vast majority of settled farmers.

Herd sizes were mostly in the range 60–200 cattle, with smaller numbers of goats and sheep. However, some particularly wealthy households said that they had 600–1000 head of cattle (not necessarily all in the Valley). Diseasees were mentioned as the most serious problem with cattle. Most households reported losing 8–10% of their herds to disease each year, with a minority reporting losses of 15–20%. Lack of availability of veterinary medicines was cited as a major issue, and some Maasai said that they regularly travelled as far as Lilongwe in Malawi to obtain medicines.

Few Sukuma children attended school, a finding similar to that of other surveys (Charnley 1998). However, most Maasai males had been to primary school, though few women had attended school. At the group discussions the problem of access to the dispensaries, which were located in the villages, far from the bomas in the floodplain, was a major concern, particularly for women.

All pastoralists reported eating meat regularly, with most eating meat 5–7 times per week. They complained that it was difficult to sell cattle in the valley, as the official market for the valley had been closed for three years due to a disease outbreak. They also said that it was difficult to sell meat informally in the villages, as people there were too poor to pay for it, and because they 'preferred the meat of wild animals'. In contrast, the pastoralists strongly expressed a preference for domestic meat rather than wild meat.

Pastoralists and conservation in Tanzania

The extent to which pastoralists are a threat to wildlife is a highly controversial topic in Tanzania. On the one hand, some people argue that pastoralists reduce wildlife populations, through competition with wild animals for grazing and water and by hunting. On the other hand some people argue that pastoralists have coexisted with wildlife for centuries and do not necessarily reduce wildlife populations significantly. There is evidence for both points of view and the general consensus is that pastoralists can in some cases coexist with considerable amounts of wildlife (Homewood and Rodgers 1991). However, there is also considerable evidence that external factors can contribute to resource depletion including 'overgrazing' and elimination of wildlife. Charnley (1998) in her detailed study of the history of pastoralism in the Usangu Flats in Iringa Region provides a useful case study. She found that Sangaa pastoralists had coexisted with wildlife for probably many hundreds of years. However, appropriation of land (elsewhere) for development projects and expansion of the area of land cultivated by farmers resulted in an influx of other pastoralists (Maasai and Sukuma) who were searching for new grazing land. She contends that in the past, the traditional Sangaa chiefs would have been able to prevent the influx of new pastoralists, or at least have some influence on the activities of the immigrants. However, the colonial administration weakened (deliberately) the traditional structures of power and authority. The result was that traditional grazing management systems were thrown into disarray resulting in an 'opening of the commons' and a more anarchic use of land. Coupled with the increase in the number of cattle, the result was significant ecological change including an increase in the prevalence of non-palatable vegetation and the virtually complete elimination of previously abundant large mammals. She also suggests that the immigrant Sukuma pastoralists used natural resources more intensively that the original Sangaa and the immigrant Maasai – they tended to have larger families and to send few children to school, enabling them to use 'free' family labour for herding cattle rather than hiring local labour as did the Masaai and Sangaa. The result was that they could build up their herds more quickly.

The implications of this for the Kilombero Valley are unclear, however, we suggest that given the relatively high rate of immigration of pastoralists into the valley, we cannot rule out the possibility of a similar scenario occurring. However, we would like to stress that we have no empirical evidence that any pastoralist group in the valley is currently contributing significantly to resource degradation or depletion of the number of large mammals. There is no evidence that a certain population of pastoralists cannot co-exist with considerable populations of wildlife. Virtually everywhere in Tanzania, pastoralists have been marginalized by both development and conservation projects, whilst receiving few if any benefits from the state. Pastoralists have on many occasions been evicted from areas of land perceived as important for conservation, without compensation and usually with little or no evidence that they are causing long-term ecological damage.

We therefore strongly recommend that no major conservation decisions involving pastoralists be taken without empirical evidence, and that pastoralists all groups of pastoralists are treated as legitimate stakeholders in both conservation and development in the Kilombero Valley. To this end we recommend that any future conservation or development programme should include provision for a detailed socio-economic and ecological study of the pastoralists in the valley. This should include study of the reasons why pastoralists have moved to the valley, their use of space, their consumption of fuelwood, their use of fire and the existence of grazing management regimes, if any.

Part 4: Interactions with wildlife

Positive interactions with wildlife

There are few legal positive interactions with wildlife in the Kilombero Valley. The District Game Office does carry out hunting to provide meat for traditional festivals, but these occur only a few times each year. Wildlife probably has considerable cultural or spiritual significance for certain groups and individuals (Jatzhold and Baum 1968), but this was not studied in this project.

However, a considerable number of people to appear to make money from the consumptive use of wildlife. Puku meat was widely available in Ifakara, and in some small restaurants in the larger Ulanga villages. Drying racks, presumably for the meat of animals, since they were far from rivers were found in several places in the valley, indicating a relatively organised trade in wild meat. However, the fact that meat was being dried suggests that it was destined for sale further afield, perhaps completely outside the valley. Gun shots were heard on several occasions in the floodplain, and a recently shot puku was found on one occasion. During surveys on the river channels, we encountered some youths heading into the floodplain armed with spears, and guns were found by the game scouts working with us at several fishing camps, including one high-powered (though old) rifle. It would therefore appear that hunting for subsistence occurs relatively widely in the valley. However, we would like to emphasise that we have no quantitative information on the extent of hunting of wild animals, nor whether it is currently sustainable.

Negative interactions with wildlife

Crop damage

When asked about problems with agriculture, all respondents mentioned crop damage by wild animals as a serious problem (Figure 5). Of these 28% ranked it as the most important problem. However, this is probably an under-estimate of the severity of this problem: the study took place in a drought year, and 45% of respondents mentioned that drought was the primary problem with their crops. Almost all of these respondents (42% of the total) ranked wild animal damage as the second most important problem. Thus, in a non-drought year, wild animal damage is likely to have been by far the most serious problem mentioned, with up to 70% of respondents ranking it as the most serious problem.

Crop raiding is also a serious problem for pastoralists, as many of them also have farms. In many cases it may be a worse problem than for settled farmers, as pastoralists farms tend to be close to their *bomas*, within or very close to the floodplain. They therefore suffer the double disadvantage of being closer to areas with high densities of wildlife, and not having other peoples' farms around theirs to act as a buffer. Of the 21 pastoralist households interviewed, 16 ranked wild animals as the greatest problem with their crops, many more than ranked drought as the greatest problem.

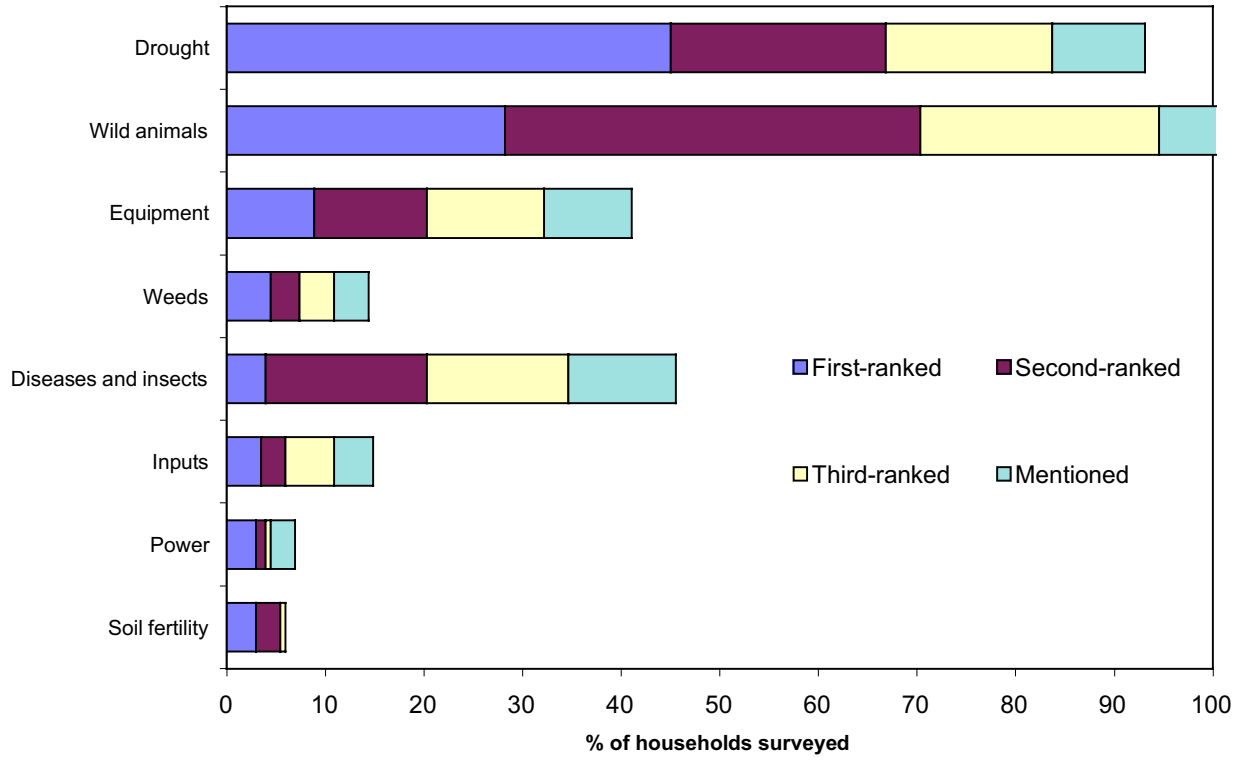

Figure 5: Village households' problems with agriculture ranked by importance (N=225)

Impacts of crop raiding

The fact that crop raiding was mentioned as an important problem by so many respondents gives an indication of how serious it was. A few lines of evidence indicate how much damage people perceive. In one group discussion[11], a participant said that *"for every 10 acres, eight acres are raided by animals and two harvested*", while in another discussion a participant said *"...very little is harvested because a large part, about _ of the shamba will be raided by animals."*

Given that people's perceptions of crop damage tend to reflect extreme events rather than the average level of damage (Naughton-Treves 1996), these estimates can be regarded as reflecting the worst cases, for example when a whole field is destroyed by elephants in one night. When discussing problems with agriculture, people were asked to estimate the amount of crops that they lost due to wild animals. Allowing for exaggeration, a conservative estimate is of the order of a sixth to a fifth of yields on average. Estimates of crop damage around the Selous Game Reserve that were based on quantitative measurements indicated that an average of a quarter of all yields were lost due to wild animals (District statistics cited in Ndunguru and Hahn 1998).

Using highly conservative estimates for crop yields and a conservative estimate of 10% of yields lost to wild animals then a 'back of an envelope' estimate of the costs of crop raiding by wild animals indicates that a total of around US$300,000 per year of crops is lost due to wild animals[12]. Using possibly more realistic estimates of the prices of rice and of the extent of crop yields, the figure could be over US$1 million. Whilst this is very much a rough order-of-magnitude estimate, the figures are plausible – the estimated average cost of US$20 per household per year in fact seems very little compared with the strength of feeling evident when people were discussing the problems of crop raiding, and the amount of time and effort spent guarding fields. The estimate of the magnitude of crop damage does not, of course, include any measure of the indirect costs of crop raiding, which are considerable (see below).

[11] Igawa female focus group held 12/8/97

[12] The calculation is as follows: value of crops lost= 1.9 ha x 0.1 x 0.5 tonne ha^{-1} x Tsh 150/kg x 1/625 US$ per Tsh x 14,000 households. The District Agriculture Office estimates average yields of 1.8 t ha^{-1}, but farmers estimated much lower yields so a highly conservative figure has been used.

When asked to rank the species of animals that caused most damage, the majority of respondents (62%,Figure 6) mentioned wild pigs, monkeys and baboons as the worst problem species, which are not animals of conservation concern in the area.

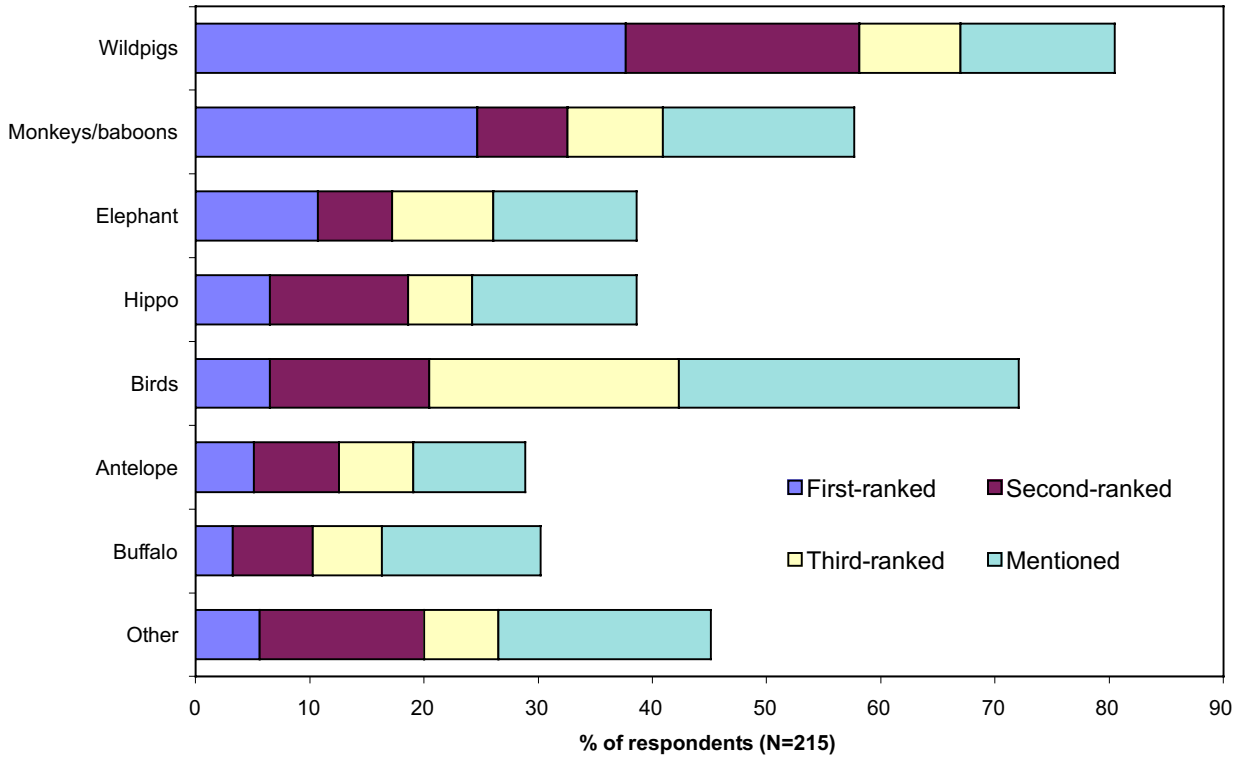

Figure 6: Animals causing crop damage ranked by importance

Comparing the extent to which different species or groups of species were perceived as problems[13] in different villages adds another level of complexity to the problem (Table 5). In Iragua and Usangule, the dangerous 'floodplain species' were ranked as being much less important than in other sites, while wild pigs and primates were of greater concern. This is probably because both villages are somewhat buffered from the floodplain by an area of woodland. Elephants were ranked higher in Lupiro, possibly because this village lies on the migration route of elephants between the Selous Game Reserve and the Kilombero Valley (UDNRO, 1997). In Itete, buffalo, elephant and antelope were perceived as more important than the average for the whole sample, probably reflecting the proximity of people's farms to the floodplain in this village.

[13] Whilst the ranking of the extent to which each species or group of species provides an indication of the extent to which the species were perceived as a problem, it does not provide much information on the amount of damage caused by each species. For example, a species ranked as of secondary or tertiary importance at one site may still cause more damage than the species at a different site where it is ranked higher. Moreover, as Naughton-Treves (1998) documents, the extent to which animals are perceived as problems is a complex function that may relate more to infrequent, extreme events and to people's perceptions of vulnerability than to the average level of damage caused.

Table 5: Weighted rank indicies of animals perceived as causing damage by crop raiding

Village	Wild pigs	Primates	Antelope	Buffalo	Elephant	Hippo	Birds
Lupiro	0.41	0.26	0.14	0.08	0.36	0.22	0.38
Iragua	0.40	0.86	0.08	0.04	0.15	0.16	0.27
Itete	0.24	0.28	0.31	0.25	0.22	0.13	0.30
Usangule	0.58	0.27	0.10	0.02	0.09	0.13	0.29
Igawa	0.81	0.11	0.03	0.18	0.12	0.18	0.25
Overall	0.51	0.33	0.12	0.11	0.19	0.17	0.30

The variation in the extent to which each species was perceived as a problem in each village may only reflect the damage caused in the farming season that had just finished when this survey was carried out. Initiating a long term programme monitoring the amount and impact of crop raiding would be an important component of any scheme aiming to reduce crop damage.

Current strategies to cope with crop raiding

The District's Game Scouts, who are employees of the Wildlife Division, are technically responsible for problem animal control. However, they are limited in their work by lack of resources (especially transport and bullets), and by their numbers – each game scout must cover a whole Division, incorporating several widely-spaced villages, within which the fields themselves are often widely-spaced and not easy to get to, especially in the rainy season. Thus it is not surprising that the majority of respondents did not feel that game scouts benefited them in terms of control of problem animals. Only 26% of respondents (N=211) saying that they received benefits from game scouts, 61% saying that they did not receive any benefit, and 13% unsure whether they received any benefit. This issue came up in all the focus group discussions and the majority of the questionnaires/interviews. For example a Sukuma man said that:

> *"If you go to the responsible people, the game scouts, since there are many people in comparison to number of game scouts, and he is called in different places, here and there, he might not come and animals are many. Sometimes you can hear him saying we have run out of bullets and it is difficult to come to your villages without bullets."* (Sukuma focus group)

Since game scouts are perceived as ineffective at controlling problem animals, and people do not have legal access to guns, defence of fields against animals is carried out through more primitive methods. The main strategy used by villagers is to build small huts on stilts (known as locally as *lingo*) within the shambas, and to stay in these attempting to scare animals by making noises, and sometimes using glowing embers to scare animals in the dark. Crop protection takes place throughout the growing season, from February though to June, and sometimes into July. Protection is mainly carried out by women and older children.

As a result, crop raiding by wild animals has major indirect effects on people's livelihoods as well the direct impacts on the crop yields. Guarding crops is a round-the-clock occupation and the amount of time that must be devoted to guarding crops reduces the amount of labour available for other activities. As one woman said:

> *"There is a problem of allocating labour… between competing needs. First, you need to stay in your shamba for scaring animals. Second, you need to take care of your children who are attending school At the same time you have different shambas and because they are located at different places, it takes a very long time to walk to those shambas."* (Itete female focus group).

The extent of the problems varies between households. In his study of strategies used to cope with crop raiding in the Kilombero Valley, Haule (1997) found that the problems are less for larger households that have more available labour. In smaller households, children are often assigned the job of guarding fields, especially at weeding time, when labour demands are highest. The result is that the children in smaller households are less likely to attend school, and the families are less able to exploit secondary livelihood opportunities (Haule 1997).

Guarding the shambas is also dangerous, resulting in injuries, and sometimes even death (see also section on injuries below). One villager interviewed for this survey described an incident that had occurred recently:

> *"...a villager was killed by an elephant when making noises to scare animals in the field. The elephant went to the hut after recognising the source of sound and demolished it. The hut [was] broken down with the farmer inside. When people came the a next day they found him dead."*

Living in the fields whilst they are flooded also has severe effects on health. As one man said:

> *"In the shambas we have difficulty getting clean and safe water and our health is endangered, we don't know what to do."*

Although malaria transmission in the valley is high all year round, with the individuals receiving more than 300 infectious bites per year, it is particularly pronounced in the farming season, resulting in loss of labour at the time of peak demand (Haule 1997).

Changes over time

There was a strong perception that problems due to wild animals were increasing over time, with 86% of respondents (N=229) saying that problems were increasing, compared to 7% who said problems were decreasing, and 7% unsure whether problems were increasing or decreasing. The majority of people who said that problems were increasing explained the increase as being due to an increasing number of wild animals. However, it is not clear whether the number of animals is in fact increasing. A more likely scenario, mentioned by several people explained the increase in problems due to wild animals in terms of expansion of the area farmed towards the floodplain, which has resulted in people farming closer to areas with high densities of animals. This would explain the perceived increase in the number of animals, as well as the increase in the number of problems.

The majority of people who said that problems with animals were decreasing explained the decrease in terms of block farming, which meant that other people's farms protected their fields.

Perceptions of changes in problems due to wild animals varied between villages. In Usangule 25% of respondents said that their problems were decreasing, a significantly higher fraction than in other villages (χ^2 test, χ^2=35.1, DF=4, P<0.001). Some people from Usangule explained this in terms of falling numbers of animals, but two balozis (ten-cell leaders) believed that the decrease was due to the increasing number of pastoralists. They indicated that the recent arrival of pastoralists had reduced pressure from wild animals because they occupied the region between farms and animals, thus providing a kind of buffer zone.

Cattle raiding

Loss of animals to lions was mentioned as a serious problem by 10 of the 21 pastoralists interviewed, second only to loss of cattle due to diseases. Of these 10, four ranked crop loss due to lions as the most important problem for their herd. However, during the group discussions with both Maasai and Sukuma, there was general agreement that loss of livestock to lions was less important than crop raiding.

Game scouts and problem animal control

As discussed in the previous chapter, the majority of respondents did not feel that game scouts benefited them, with only 26% of respondents (N=211) saying that they received benefits from game scouts, 61% saying that they did not receive any benefit, and 13% unsure whether they received any benefit. However, these summary statistics mask considerable variation in the perception of benefits from game scouts.

Perception of benefits from game scouts was significantly related to the wealth index, with poorer households much less likely to report receiving benefits (Anova with log transformation, F=4.81 on 1DF, p =0.03). The median wealth score of households reporting a positive benefit was 7, whilst that of households reporting no benefits was 4. Although the service provided by game scouts is supposed to be free and available to all, in practice they can be reluctant to perform dangerous jobs without material reward, which is perhaps not surprising as their government pay is low and irregular. This is illustrated by a respondent from Lupiro, who said:

> *"[Game scouts] just ignore you and say you should have to contribute some money for them to help you.*

The distribution of benefits from game scouts also varied by location (Table 6). The perception of benefits from game scouts varied significantly between villages (χ^2 test, χ^2=32.5, DF=8, P<0.001). Game scouts were most highly thought of in Usangule, where 49% of respondents thought scouts benefited them, as opposed to 35% saying they did not. However, in Igawa the vast majority of respondents (87%) thought game scouts did not benefit them and only 9% thought that they received any benefit from game scouts. This is probably due to the remoteness of Igawa, which increases the amount of crop raiding, and makes access for scouts difficult. Crop raiding by wild animals is greatest during the farming season, when the valley is still partially flooded. The road connecting Igawa with Malinyi, where the nearest game scout is based is then impassable as there is no bridge.

Table 6: Perceived benefits from game scouts by village

	% of respondents mentioning		
Village	**No benefit**	**Benefit**	**Unsure**
Lupiro	61	27	12
Iragua	67	26	7
Itete	46	28	26
Usangule	35	49	16
Igawa	87	9	4
Overall	**61**	**25**	**13**

The perception of the effectiveness of game scouts also varied depending on the sex of the respondent (rather than the head of household), with only 19% of women saying that they benefited from game scouts as opposed to 35% of men (χ^2 test, χ^2=9.975, DF = 2, p = 0.007). This may be because women tend to spend more time than men defending fields from raiding animals (Haule 1997), so their perception of the problems is greater, or because game scouts are more likely to respond to the demands of males.

Injuries

Injuries from wild animals are a significant problem for people living in the valley. Many injuries are not treated in hospitals and so go unreported and do not figure in official reports even where these exist. Few respondents reported injuries directly to themselves or to a household member, but 31 respondents knew other people who had been injured (Table 7). From the details given, 24 separate incidents can be identified as occurring between 1995 and mid-1997, including 9 deaths. The deaths were caused by lions, hippos and crocodiles. Whilst minor incidents are unlikely to be reported and recalled, it is reasonable to suppose that major incidents, especially deaths, within each village are widely talked about, so the number of major incidents and number of deaths recorded are probably fairly good indications of the actual number.

The high rate of deaths can be illustrated by comparison with total number of deaths recorded from around the entire 45,000km^2 Selous Game Reserve: an average of 10 deaths are recorded annually (Ndunguru and Hahn 1998). Given that this survey studied fewer than half the villages on the Ulanga side of the Kilombero Valley, this indicates that the total number of deaths per year due to wild animals in this area could approach the total number around the Selous Game Reserve.

Table 7 : Reports of injuries due to wild animals 1995–Mid 1997

Village	Number of incidents	Number of deaths
Igawa	9	4
Iragua	5	0
Itete	1	2
Lupiro	6	0
Usangule	3	3
Total	**24**	**9**

Interviews indicated that many injuries occurred during particular activities. As also found by Haule (1997), many injuries occurred whilst people were fishing. However, many others occurred when crossing rivers or streams where there was no bridge, for example on the path from Igawa towards Kilosa kwa Mpepo, and when canoes could not be used (for example when herding cattle). If conservation revenues (from safari hunting, for example) were used to repair broken bridges, or to build new ones at critical points, this could improve people's perceptions of some conservation activities.

Attitudes to conservation

Should animals be preserved?

Despite the overwhelmingly negative relationship between people and wildlife, a majority of people (53%, N=229) said that wildlife should be preserved, compared to 30% saying that it should not be preserved, and 17% unsure. The vast majority of people who did not think animals should be preserved justified this by saying that animals raided their crops and caused injuries, but people received no benefits from them. The most frequent reason given for preserving animals was for the benefit of future generations, though reasons such as 'a source of foreign exchange for the government' and 'to attract tourists' were also given.

Opinions about whether wildlife should be preserved varied between villages (Table 8), with a majority (56%) of respondents from Igawa, a floodplain village, saying that wildlife should not be preserved (χ^2 test, χ^2=41.5, DF=8, P<0.001). This could be due to the higher number of injuries experienced by people in this area (Table 7 above).

Table 8: Attitudes towards preserving wildlife

	% of respondents saying:		
Village	**Preserve**	**Don't preserve**	**Not sure**
Lupiro	66	22	12
Iragua	56	32	12
Itete	47	12	40
Usangule	64	21	14
Igawa	35	56	9
Overall	53	30	17

However, the ability of such simple questions to 1) adequately summarise people's attitudes to wildlife and 2) predict people's willingness to participate in conservation schemes, is questionable. Many respondents may simply have been saying what they thought we wanted to hear (especially as we had Wildlife Officers on the team), whilst others may have been parroting slogans that they had heard on the radio. Thus these responses should be treated with caution, and it should be recognised that even if people are in favour of conservation in principle, there are many different factors that can prevent the principle from being transformed into concrete action.

Part 5: Local politics: inequalities in power

Inequalities in power and access to benefits

The ability of a majority of resource appropriators to influence the rules and decisions made concerning resource management and the existence of a low-cost arena within which to resolve disputes are key criteria for successful management of common property resources (Ostrom 1990). Community-based conservation programmes such as that under discussion for the valley often create wildlife management committees or similar to oversee management of wildlife and more importantly wildlife-derived revenues. The Selous Buffer Zone programme on which any conservation initiative for the Kilombero Valley is likely to be based creates a Village Wildlife Committee, chosen using the same procedure that is used to elect the Village Council (Ndunguru and Hahn 1998), so the extent to which the village council is regarded as effective and representative provides an indication of how Village Wildlife Committees may be perceived by ordinary villagers. This section therefore discusses villagers' perceptions of the various committees and councils that make up the local government. It is not our place to comment on the validity of people's perceptions, but the fact that they arose often spontaneously within group discussions indicates that they are based on deep-seated feelings.

Composition of the councils

In the study villages access to power and control over resources is extremely uneven, with wealthier people much more able to command power. A minority of households (20%) had a member on the village council. Those that did have a member on the council were significantly wealthier (mean vs, median vs; Anova with log transformation, F=5.42, p=0.02). Only 9% of the poorest 25% of households were represented, compared to 29% of the richest 25% and 45% of the richest 5% of households. Female-headed households had a smaller proportion of members on the village councils (12% vs 20% for the whole sample), but this was not statistically significant (_^{2} test, _^{2}=1.11, DF=1, P=0.29).

That the village and local governments are seen as remote from the concerns of ordinary people was reinforced by the group discussions (Box 1), with the village government regarded by ordinary villagers as "*deaf to our problems",* and village leaders as *"not effective in carrying out their responsibilities"*.

Box 1: Quotes from group discussions illustrating ordinary villagers' perceptions of the village government

"Sometimes pastoralists graze their livestock into our shambas, making complaints to the village government doesn't help because pastoralists pay a bribe to the village government. This makes the village government deaf to our problems." (Itete female focus group)

"When they [pastoralists] are sent to court they bribe police and judges, and are left free. ... The government at Division and District level are bribed too, and so they don't work against pastoralists." (Igawa female focus group)

"...there are problems with the village government, they don't want to organise and call village meetings." (Igawa male focus group)

"We talk a lot about development issues, but nothing is being carried out, so villagers' hearts are being broken by village officials....the village is getting a lot of help from various people, but district officials are busy benefiting at the expense of local people" (Usangule informal focus group)

"Village leaders are not effective in carrying their responsibilities. There are reports made to District and Ward officials on pastoralist problems, but they say we will come to your shamba to see how severe the problem is, later they don't come to your shamba, but they go to pastoralists secretly and get bribe from them and nothing will be done." (Usangule informal focus group)

These types of feelings seemed to be repeated with respect to the District Council. One individual at a group discussion in Iragua said, *" if you think there is something to help local people from you, please! Send it directly to the intended group of people rather than channelling it via higher levels of government officials like the Ward, Division or District. If this happens we do not see anything."*

Thus the general impression is that the Village Council and higher levels of government are regarded as unaccountable to the interests of ordinary villagers. This suggests that at the least, these councils have a severe public relations problem. A key component of any community-based conservation scheme is a set of management institutions that are perceived to be transparent and accountable so the implications of this finding are discussed in more detail below.

Part 6: Discussion: 'community' conservation?

In summary, the principal findings of this survey are:

1) Although most villagers in the valley are poor and most depend on the same natural resources, there are considerable differences within villages in people's levels of well-being, for example as measured by the ability of households to provide for their own food needs.
2) Wildlife in the valley causes considerable amounts of crop damage and hardship for farmers and frequent injuries and even deaths. The indirect costs of having to protect fields against wildlife are also high. Together, these result in considerable resentment towards wildlife. However, whilst 'floodplain species' such as elephants and buffalo cause severe damage to crops, smaller, non-protected species such as bushpigs and baboons cause damage most frequently.
3) Since there are so few game scouts, who are underpaid and under-equipped, they are not perceived as being effective in controlling problem animals.
4) The number of pastoralists in the valley appears to have increased rapidly over the last ten years. Pastoralists are generally materially better off than the farmers in the villages, but also suffer from cattle loss and crop damage due to wildlife, and lack of access to medical and veterinary services.
5) There is widespread resentment of pastoralists by farmers, due to damage to farmers crops (real or perceived) by pastoralists' cattle, and difficulties in pursuing claims for compensation when damage does occur.
6) Village committees and other political bodies are perceived as serving the interests of the village elite and as being unaccountable and insensitive to the needs of ordinary villagers.

This section of the report discusses the implications of these findings for the possibility of setting up a community-based conservation initiative in the Kilombero Valley.

What is community-based conservation?

Although 'community-based' conservation is currently in fashion in conservation thinking, and virtually all new conservation schemes involve a 'community' component, what 'community-based' conservation actually means is often far from clear, and many different types of schemes are sometimes lumped under the same title. A clear conceptual distinction can be made between so-called 'Integrated Conservation and Development Projects (ICDP's)' and 'Community-based conservation (CBC's)':

- *Integrated Conservation and Development Programmes* are based on the premise that providing alternatives to practices that are currently detrimental to wildlife is the key to ensuring their conservation. The assumption is that if alternative ways of making livelihoods, such as intensive livestock raising or bee farming can be introduced, people can be encouraged to reduce their dependence on natural resources and thereby contribute towards conservation. Thus these types of programmes attempt to provide alternative livelihood options (through training programmes, credit schemes etc) that will both improve people's livelihoods (development) and in doing so will reduce peoples' use of natural resources. Support for alternative livelihood activities is not necessarily funded by revenues raised directly from conservation.
- C*ommunity-based conservation* schemes are based on the premise that wildlife is potentially a valuable resource and if people receive benefits from the presence of wildlife, or intact ecosystems, they will have an incentive to moderate their resource use practices to maintain those benefits at a sustainable level. Schemes of this type therefore try to create an institutional framework (of national and local laws, agencies etc) that allow people living in wildlife-rich areas to benefit from wildlife for example through revenues from safari hunting, photographic tourism or sale of game meat. The assumption is that if people receive sufficient benefits, they will be motivated to moderate any practices that are currently detrimental to wildlife and will eventually become involved in policing use of the resource themselves. Within this general framework, there are a variety of different types of scheme, varying from ones that give local communities complete ownership of wildlife and control over benefits from them, to ones in which most control is retained by the state or an external agency, and communities are largely passive beneficiaries of wildlife-

derived benefits. These schemes are usually, but not always, implemented in areas adjacted to protected areas such as national parks, and are often referred to as 'buffer zone schemes'.

At the time this study was conducted, the type of conservation programme most likely to be introduced in the Kilombero Valley, is one based on the pioneering scheme currently in existence around the Selous Game Reserve. This scheme uses a variety of legal instruments to permit hunting and return some safari hunting revenues to communities in anticipation of a more formal framework when the Tanzanian Wildlife Act is updated. Billed as 'conservation by the people, for the people' (Baldus 1988), the Selous Buffer Zone scheme falls in the category of 'community-based conservation'. Since this scheme is likely to serve as a starting point for any community-based conservation programme in the Kilombero Valley, we will describe it in detail, and then use the information collected in this study to assess the likely outcomes of such a scheme.

Outline of the Selous Buffer Zone community-based conservation scheme

The Selous Buffer Zone community-based conservation scheme has been implemented in several buffer zone areas adjoining the Selous Game Reserve that is adjacent to the Kilombero Valley. It aims to reduce pressure on the Game Reserve by maintaining wildlife populations outside the reserve through limiting illegal hunting and zoning the use of land for agriculture. The scheme has the following components (Ndunguru and Hahn 1998):

- Preparation of land use plans for each village, including legal demarcation and production of title deeds. Within this land use plan, Wildlife Management Areas (WMAs) are defined, in which agriculture is prohibited by a local bye-law.
- For each village a village game scout is trained and equipped with a rifle with which to carry out hunting and problem animal control. Village scouts are normally 'young men of good standing in the village' (Ndunguru and Hahn 1998). Villages are expected to pay for the bullets to shoot animals, in order to 'impart an awareness of cost effectiveness'.
- In return for prohibiting agriculture on some areas of village land, an annual quota of animals to be hunted for meat is granted to the village by the Wildlife Division. The quota is hunted by the village game scout and the meat sold in the villages. Money accruing from the sale of the meat is put into a village development fund.
- A village wildlife committee will be established to manage the hunting of the quota and disbursement of the revenues. The wildlife committee is elected by the village assembly, but is answerable to the village council.
- A proportion of the revenues from safari hunting in that village's lands (currently 19%) are returned to the area. This is currently paid to the District Council rather than to the villages themselves, but it is hoped that the new wildlife act will allow funds to be returned directly to the villages.

The programme thus aims to create incentives for conservation by:

- Providing a legal supply of meat for sale in the villages
- Returning a proportion of revenues from safari hunting back to the local area, these may be distributed to villagers or used for community projects at the discretion of the District Council
- Increasing the number of game scouts available for problem animal control.

Whether these will be effective or not at changing people's behaviour depends on people's responses to these 'benefits'. From the description of the programme given above, some of the assumptions of the scheme can be restated as hypotheses:

1) There is an unmet demand for game meat. People will be willing and able to buy game meat. The availability of legal meat will cause people that currently hunt illegally to stop doing so.
2) The revenues from the sale of game meat and funds from safari hunting will be disbursed by the village council in ways that will benefit the majority of people in the communities. People within the communities will associate this benefit with the presence of wildlife.
3) Increasing the number of game scouts available for problem animal control will reduce the costs of living with wildlife, and will cause people to be more accepting of living with wildlife.
4) People living in the valley will associate all the above benefits with conservation. The benefits (and the promise of future benefits) will be sufficient to cause people who currently hunt to stop hunting

illegally, to refrain from land use that is not compatible with wildlife, and to attempt to prevent other people from doing the same. Even if illegal hunting is not eliminated entirely, it will be reduced to a sustainable level.

Combining the socio-economic information that we have gathered with experiences from other conservation programmes allows us to use these hypotheses to structure a discussion on the potential for community-based conservation in the Kilombero Valley. Note that the assumptions in this section are that the goal of conservation is the long-term preservation of substantial and viable populations of large mammals, and further assumes that the main threats to these are 1) hunting of animals for food and 2) an increase in the number of pastoralists and their cattle (rather than expansion of farm land). The extent to which these assumptions are valid are discussed in the general conclusion to this report and in the 'Mammals' section.

The provision of game meat as an incentive for conservation

One of the possible ways of creating incentives for sustainable use of wildlife is through providing meat for sale though hunting quotas for each village. Within the villages there is considerable demand for wild meat, but assess the potential effectiveness for provision of wild meat as an incentive for conservation, we need to consider two things: 1) the amount of meat available and 2) its distribution.

Amount of meat available

We do not have detailed enough information to suggest approximate hunting quotas for each village. An accurate assessment would require more detailed knowledge of spatial and seasonal variations in animal abundance, mortality to predators and levels of illegal hunting. However, rough 'guestimates' can be made to illustrate the approximate amount of game meat that is potentially available. Charlwood (1996) uses an estimate of 55,000 puku in the whole valley (a relatively high figure from aerial surveys) to suggest that a sustainable total of 56,000 kilograms of meat would be available annually. It should be emphasised that this is very much a 'guestimate', and the actual possible sustainable offtake could be much lower, or (less probably) higher[14]. Assuming that was practical to harvest this amount of meat, and that half the puku in the Kilombero Valley are found in the Ulanga District side, this means that a 25,500 kilograms of puku meat would be available for villages in Ulanga District. With approximately 93,000 people in the 11 villages bordering the valley in Ulanga District, this equates to less than *one third of one kilogram of meat per person per year*. If residents of Ifakara are treated as legitimate stakeholders in the wildlife resources of the area and receive an allocation of game meat as well the amount would be even less.

The total amount of meat available could be increased if other animals were included, but it should be noted that the actual harvest of meat would need to be considerably less than Charlwood's estimate if offtakes were to be sustainable in order to 1) take account of year-to-year fluctuations and 2) the fact that a number (possibly a large number) of other animals are hunted illegally. A further problem is that puku and other animals are not distributed evenly in the valley (see the Mammals section). To avoid the risk of local extinctions of animals, hunting intensity needs to match the density of wildlife. This means that either 1) transport needs to be provided and the pattern of hunting strictly controlled or 2) each village would have a different quota of animals to be hunted based on the number of animals the vicinity of the village. In this case each village would receive different amounts of meat – some more and some less.

The point of the above discussion is to point out that even if the potential productivity of animals in the area was *4 or 5 times* higher, the amount of meat that each person or family would receive would be very small. Provision of meat would certainly be welcomed in villages, but whether it would be sufficient to provide significant incentives for conservation is debateable. Another problem is that the human population of the area is growing, but the animal population is likely to (at best) remain constant, so the available yield per person will gradually decline.

[14] Charlwood's (1996) estimate is based on hunting adult puku, however maximum productivity is normally achieved by selecting animals that are about 1 year old, since their growth rate is greatest in the first year of life. Therefore the theoretical maximum sustainable yield could well be greater than Charlwood's estimate. However, as discussed in the text, the need to take account of population fluctuations and losses to natural predators and poachers means that the actual amount of meat available on a sustainable basis is unlikely to be significantly more than his estimate.

Distribution of meat

Even if there was enough meat, our study indicates that its distribution is likely to be problematic. The considerable variation in wealth in the villages, with the poorest people not even able to eat beans frequently, implies that a considerable portion of the villagers would be unable to afford the meat if it was sold. Indeed, Gillingham's (1998) study of the distribution of wild meat in the context of the Selous Game Reserve Buffer Zone Programme found exactly this problem. She also found that this was compounded by the fact that the Village Wildlife Committee rarely made any meat there was available to even the villagers that could pay for it. Our findings concerning the perceptions of the Village Councils and other political bodies in the area indicate that this is also likely to occur in the Kilombero Valley unless specific steps were taken to assure equitable distribution of game meat.

. Moreover, there is anecdotal evidence that at least some households can currently obtain wild meat free or cheaply, albeit illegally. For example, several pastoralists complained that they found it hard to sell meat from their cattle in the villages because of competition from readily available wild meat. If people can already obtain game meat cheaply, they are unlikely to stop doing so because it becomes available for sale, especially if the amount of meat available is relatively small.

As we found, pastoralists in the valley claim to eat little or no game meat, and so provision of game meat is unlikely to be an effective incentive for them.

Therefore, our findings shed considerable doubt on whether provision of game meat at a village level would be effective in changing peoples' attitudes, and more importantly, actions towards conservation.

An alternative use of the available wild meat would be to transport it to urban centres where it would fetch a higher price, and return the revenues to people in the valley. Indeed, Charlwood (1996) suggests that formalising commerce in Puku meat and providing it to restaurants in Dar-es-Salaam where it would be served as a delicacy, with villagers as stakeholders in the project could be a viable option. However, it should be noted that such 'wildlife ranches' have been tried in many areas of Africa and have only been profitable in certain very specific situations – where wildlife can be procured at low cost, easily and cheaply transported to an urban centre which has a regular and significant proportion of tourists prepared to pay a high price for the meat. None of these criteria would appear to hold for the Kilombero Valley: it is difficult to move around in the floodplain, so procurement of the meat is likely to be expensive, especially if prey are to be selected by age and sex and carcasses to be processed within hygienic time limits; the road to Dar-es-Salaam, whilst it is being upgraded, is still poor; and Dar-es-Salaam does not have a large, regular tourist population prepared to pay a premium for game meat. Commercial sale of meat in this way would therefore seem unlikely to be profitable, let alone provide significant revenues for conservation.

Using safari hunting revenues for to promote conservation

Returning revenues from safari hunting and the sale of game meat to communities is another way in which wildlife-derived revenues can be used to promote conservation. As with providing game meat both the amount of revenue available and the way in which they are used are important. There are a number of ways in which revenues can be returned to communities, which depend on the legislative framework within which a community-based conservation programme works. In some programmes revenues are used to pay for community projects (schools, clinics etc), while in others money is shared out and paid to individuals. The current interim framework used by the Selous Buffer Zone Project, which could be adopted in the Kilombero Valley returns about 19% of game fees to the District Council of the area surrounding the hunting block. In future, a new wildlife policy may allow revenues to be channelled directly to villages, and perhaps a larger proportion of revenues will be returned.

The current annual revenues from safari hunting in the Kilombero South hunting block in Ulanga District are of the order of US$100,000 (Table 9). The following sections discuss the potential ways in which these revenues could be used and distributed.

Table 9: Hunting quotas and game fees in Kilombero South hunting block in 1997

Species	Quota per season	Game fee (US$)	Total annual revenue if quota is filled (US$)
Buffalo	60	600 for the first 790 for the second 840 for the third	42,000
Lion	6	2000	12,000
Leopard	2	2000	4,000
Crocodile	8	840	6,720
Hippo	10	840	8,400
Puku	12	265	3,180
All other species			14,000 (est)
Total			**90,300**

Under the current legal context the revenues available to be returned to the valley would be of the order of US$20,000 per year. This equates to less than one dollar per household per year. Even if all game revenues were returned to the valley, the figure would be less than $5 per household per year. This is extremely unlikely to be a sufficient amount to convert local people into conservationists. A comparison with the estimated costs of crop-raiding is instructive. A conservative back-of-the-envelope calculation suggested that the annual cost of crop damage could be of the order of US$300,000, and is probably far higher. The estimated annual revenue earned from game fees is US$100,000. Even if these revenues were doubled, which is probably impossible in the short term (Price Waterhouse 1996), and if all the revenues were channelled directly to the villagers, they do not come near the cost of compensating people for the loss of crops to animals.

The 'community-based' conservation schemes that appear to have been most successful are some of the Communal Areas Management Programme For Indigenous Resources (CAMPFIRE) schemes in Zimbabwe. These schemes receive far higher revenues from safari hunting than are possible in the Kilombero Valley, mostly because of the presence of elephants of trophy size. In fact, 90% of their revenues come from the hunting fees for elephants. In the Kilombero Valley, there are currently no elephants of trophy size (apparently partly a feature of the area as well as a legacy of widespread hunting in the 1980's), so the prospects for generating these kinds of revenues are slim. Moreover, in the successful CAMPFIRE schemes (there are many unsuccessful Campfire villages, a point that is not always well-publicised), the revenues are divided among much smaller populations that there are in the Kilombero Valley.

The potential for the revenues that are currently generated by safari hunting in the Kilombero Valley to contribute to conservation if distributed equally among villagers (and pastoralists) therefore appears to be low. An alternative method of distributing the revenues would be to use them to fund community-projects – US$20,000 is easily enough to provide a new school and teacher in a village for example. Some conservationists suggest that more obvious benefits such as this could have a greater impact and so be more successful in promoting conservation.

Wildlife-funded community projects

Community projects funded by wildlife-derived revenues are often promoted as effective ways to gain support for conservation as they can transform limited revenues into 'highly visible symbols of the benefits of conservation' (Lewis and Phiri 1998). Such projects could include the building of clinics or schools, funding the salary for a teacher, providing water pumps and other similar community-level projects. In certain villages, notably Igawa, river crossings are a problem and cattle and sometimes people are lost to crocodiles. The repair of bridges could be a popular and effective use of wildlife-derived funds. In the Kilombero Valley, the revenues available from wildlife could probably fund some such projects and make some contribution to development in the area. However, their ability to promote conservation is debatable because 1) such benefits are provided as 'public goods', 2) much hunting is probably carried out by people who are not from the communities that will benefit from conservation, 3) unless pastoralists are targeted specifically they are unlikely to benefit

significantly from any community projects and 4) the revenues available for such projects from conservation are low compared to that of other development projects. These issues are discussed in more detail below.

Public goods

A major difficulty with community-based conservation schemes is that wildlife-derived benefits (meat, revenues, community projects) are usually provided as 'public goods' (Gibson and Marks 1995). In other words, receipt of the benefit is not directly linked to conservation behaviour – for example a family that includes a poacher is likely to receive as much benefit from a wildlife-funded school or clinic as a family that does not. There is therefore a temptation for people to 'free ride' and attempt to receive both legal wildlife-derived benefits as well as revenues from illegal use of wildlife.

The implication of this is that unless poachers are specifically targeted and deprived of wildlife-related (and possibly other) benefits, these benefits are unlikely to provide an effective incentive to prevent illegal use of wildlife. To achieve this requires either external enforcement, or policing by village members themselves. External enforcement would require a significant investment in time and effort and is likely to stir up local resentment. Internal enforcement requires, among other things, that people receive sufficient benefits from wildlife that they are prepared to report any infringements of rules by their close neighbours. Given the potential levels of revenues, and the potential problems with distribution discussed above, this is unlikely to be the case.

Who is hunting?

Another significant issue is that of the identity of the people who are carrying out illegal hunting. As discussed earlier, there appears to be some hunting for subsistence and some hunting that is more organised and often for external markets. If such people are not residents of the villages in the valley, then provision of benefits to the villagers is unlikely to stop these hunters. We were able to speak to one hunter/poacher in Ifakara (who has since been shot and killed by an anti-poaching patrol) and this interview suggested that the hunters who provide meat to Ifakara and further afield are based either in Ifakara itself, or are people who are from areas external to the Kilombero Valley. If such people are responsible for the majority of hunting in the valley, as would seem likely, then a community-based conservation programme is unlikely to be able to significantly reduce the level of hunting. Stopping or limiting such hunting can probably only be achieved by regular and effective enforcement.

Incorporating pastoralists

A similar problem applies to trying to use community development projects as an incentive for pastoralists to control their grazing. Any 'community' projects, would almost certainly be based within the villages, since the revenues would be controlled by Village Wildlife Committees. Thus the location of pastoralist *bomas* means that they are unlikely to receive much lower benefits from any such schemes due to the long distances to them, as was mentioned by pastoralists in relation to the existing dispensaries. Some of the possible threats to wildlife that were identified were the actions of pastoralists (increasing numbers of cattle, cutting of trees etc), so ensuring that pastoralists receive benefits from conservation is an important component any community based conservation scheme. Creating incentives for pastoralists to comply with the wildlife management schemes would require projects providing veterinary drugs or dipping services or other of the pastoralists needs.

However, it is not clear whether a community-based conservation scheme would have the means and capacity to achieve this type of development. The pastoralists are, in general, relatively wealthy, and the problems that they face are often not simply related to lack of money, but to external factors that wildlife revenues would not necessarily be able to alter. For example, the pastoralists we spoke to were prepared to pay well over the official market price for veterinary drugs, and to travel as far as Lilongwe to get them because the problem was the supply of the drugs rather than the ability to pay for them.

Other development programmes

This relates to a more significant point: the potential revenues available from wildlife are small relative to potential revenues from development programmes. Given that several development projects have and continue to operate in the Kilombero Valley (eg an Islamic organisation was providing village water-pumps whilst we were in the area), any conservation project might simply be seen as another development project, making it difficult for people to make the conceptual link between development and conservation (see Stocking and Perkin 1992 for similar examples). Given that other development projects in the area are likely to continue (and we strongly recommend that they do), the effects of wildlife-derived revenues are likely to be swamped by the

activities of these projects. In this case, why should people pay the short-term costs of living with wildlife to obtain development benefits when they could just wait for the next development project to come along?

Using wildlife derived revenues to fund problem animal control

As we found, wild animals in the Kilombero Valley have a considerable impact on people's lives, both through crop destruction and the indirect costs of having to defend fields from animals. Limiting these costs would therefore appear to an effective use of conservation revenues, and from a development or humanitarian perspective, reducing the impact of wild animals should be a priority.

The provision of extra village game scouts (possibly funded by safari hunting revenues) might go some way towards controlling problem animals. Indeed, in open discussions following each questionnaire a large majority of respondents (76%), said something along the lines of 'bring back game scouts, if this is not possible, train local people as scouts'. However, given the wide spread distribution of many people's farms, the difficulty of movement during the farming season when the fields are flooded, and the fact that most crop raiding takes place by night, it would require several well-trained, well-equipped and motivated (ie paid well and regularly) game scouts per village to substantially reduce the incidence of crop damage.

Although the initial capital costs would be high, the development benefits to local people of game fences surrounding and protecting village lands would be great, especially if space within them was allocated for pastoralists to bring their cattle in at night. Improved crop yields and the potential health and educational benefits for people due to time saved from guarding fields could be significant. Such a scheme would not necessarily promote long-term conservation in itself, but the immediate and considerable benefits would certainly be likely to make people more amenable to conservation if it was obvious that the fences were provided by a conservation project, as long as the location of the fences was negotiated carefully in a participatory manner. Such an approach has been successful in some CAMPFIRE areas in Zimbabwe.

There might be technical problems with installing a game fence, especially due to the flooding regime. Nevertheless, from a development perspective, it would probably not be an overstatement to say that if it was feasible, providing (and maintaining) such game fences would probably **be the single most effective means of improving peoples' levels of well-being over a relatively short time span.**

Other considerations

As well as the issues discussed above, there are some more general issues that any community-based conservation programme would have to take account of. These are discussed below.

Power and control over resources

A key lesson from community-based conservation projects is that they are most likely to be successful when the potential recipients themselves have control over disbursement of the revenues. This requires that 1) conservation programmes and higher levels of government (District Councils etc) are willing to channel revenues to villages and to allow villagers to decide how they are spent and 2) there exist transparent and accountable village-level institutions to disburse the funds who's decisions the majority of villagers will respect. In this section we will assume that revenues will be channelled to the villages by the district council.

In the Selous Buffer Zone Programme, the task of managing the use of the wildlife quota and disbursing revenues is entrusted to a Village Wildlife Committee, which is usually similar in composition to the Village Council. In this study, the impression was that the Village Council and higher levels of government are widely regarded as unaccountable to the interests of ordinary villagers. Entrusting a committee with substantially the same make up with the task of disbursing income from the sale of wild meat or the revenues from safari hunting would thus seem to be unlikely to be effective. Given that the committee is dominated by wealthier people who are perceived to be acting in their own interests rather than that of the village as a whole, it is likely that any 'community' projects based on the use of wildlife resources would reflect the interests of the village elite rather than the poorer majority. In this case, conservation would provide few, if any, incentives for the poorest households. Experience from other conservation schemes in Tanzania (Gillingham 1996, 1998), Zambia (Gibson and Marks 1995, Lewis and Phiri 1998) and Zimbabwe as well as elsewhere indicate that this is a very likely occurrence. The lesson from these schemes is that where revenues are being disbursed, people are far more likely to be satisfied with the way in which they are used if decisions are made on the basis of participatory democracy (ie all potential recipients are involved, for example in a vote on decisions) rather than

if decisions are made on the basis of representative democracy (eg by a committee, even if that committee is elected).

Incorporating pastoralists

The number of pastoralists in the valley appears to be increasing relatively rapidly. While we have no hard evidence to suggest that they are destructive to wildlife, if their numbers increase significantly more, we believe that wildlife populations are likely to decline, as has already happened following a similar influx of pastoralists on the Usangu Flats in Iringa Region (Charnley 1998). Developing and promoting a comprehensive grazing management plan is therefore a key aim for conservation in the area.

As discussed above, use of benefits from conservation for pastoralist-specific projects could be a way of promoting such schemes. However, given the conflicts between agriculturalists and pastoralists, it is hard to believe that without specific measures to encourage it, village-based committee's would devote a significant amount of the limited revenues to pastoralist-specific schemes. Any institution for disbursing wildlife revenues created by a conservation programme must therefore take account of pastoralists as equal stakeholders and ensure that they are represented on any decision-making bodies.

All over Tanzania, the ecological requirements and effects of pastoralists have been poorly understood, and have often been based on prejudice and ideology rather than rational judgements (Lane 1996, Homewood and Rodgers 1991). The result has been their eviction from traditional grazing areas, both by conservation projects and development projects, often with little real justification and no compensation. Such pressures are one of the reasons why pastoralists are moving to the Kilombero Valley. Indeed one pastoralist said that they were moving to the area because they had been evicted from a conservation zone around Ruaha National Park. Whilst we would not wish to overly romanticise pastoralists, and it is clear that they can sometimes have destructive ecological effects, it is clear that pastoralists can sometimes coexist with significant populations of wildlife (Homewood and Rodgers 1991). We would therefore like to emphasise that pastoralists, of whatever ethnicity, should be treated as legitimate and equal stakeholders in both conservation and development. To this end, a detailed socio-economic study of the reasons why the pastoralists are moving to the Kilombero Valley and of their use of the rangeland, including both ecological factors (preferred grazing areas, grazing intensity) and social factors (grazing management regimes, household composition etc) is an essential component of any programme aiming to produce a conservation management plan. If carried out in a participatory framework (but also including more quantitative data collection), this could be the basis for building trust with resident pastoralists and developing grazing management plans.

Conclusion

In summary, the points we have made are:

- The amount of wild meat available is probably too small and the problems of distribution too great to provide significant incentives for conservation. Commercial cropping of game meat for urban markets is also unlikely to be profitable.
- The current and potential per capita revenues available from safari hunting are almost certainly too small to counterbalance the costs of living with wildlife and so are unlikely to provide a significant incentive for conservation.
- Community projects funded from safari hunting revenues could provide visible and locally significant contributions to development. However, they are unlikely to provide a significant incentive for conservation because 1) such benefits are provided as 'public goods' so receipt of benefits is not directly linked to conservation behaviour, 2) much hunting is probably carried out by people who are not from the communities that will might from conservation, 3) unless pastoralists are targeted specifically they are unlikely to benefit significantly from any community projects and 4) the revenues available for such projects from conservation are low compared to that of other development projects.
- Using wildlife revenues to fund extra community game scouts could reduce problems for crop raiding, but only if there were several well-trained and motivated (well paid) scouts per village.
- Construction of game fences around village farmlands could provide significant and immediate benefits to local villagers through reduction in the direct and indirect costs of crop raiding.

Our conclusion is therefore that it is unlikely that a conservation scheme modelled on the Selous Game Reserve Buffer Zone programme would be an effective conservation tool for the Kilombero Valley **if it is the only conservation action that is taken**. The potential level of benefits available from wildlife are probably too low compared to the current costs of living with wildlife, and the problems of distribution of the benefits are probably too great for wildlife-derived benefits alone to convert local people into conservationists. To borrow a phrase from CAMPFIRE, 'the ecological and social topography' do not match. However, the implication of this is not that communities should not be involved in conservation; indeed, we suggest that it is essential that they are. The point that we would like to make is that any conservation scheme needs to be focused on local realities, and blueprint conservation is unlikely to be effective. In the Kilombero Valley we suggest that the following points need to be taken into account:

- The costs of living with wildlife are very high relative to the potential amount of mean or money available from wildlife. A focus on reducing these costs is therefore more likely to provide tangible benefits to people than a focus on returning revenues.
- Existing institutions of governance are perceived as being unaccountable to the needs of ordinary villagers. When devising new institutions for managing wildlife and land use, it is important to make sure that they are perceived as accountable and transparent and that ordinary villagers can influence them at a low costs (in terms of time and effort). Experience shows that in these cases institutions based on the principle of participatory democracy rather than representative democracy are more likely to be successful.
- Pastoralists have tended to be marginalized from development projects. Any institutions for wildlife and further wildlife management must therefore recognise that pastoralists have a legitimate and valid stake in the both development and conservation schemes. Any conservation scheme therefore needs to be proactive in including pastoralists.

The people of the Kilombero Valley are for the most part poor and live a tough existence, attempting to cope with destructive abilities of wild animals, droughts, floods and disease. Whilst wildlife-derived benefits might be able to ameliorate some of these problems, it is probably unrealistic to expect them to completely counteract the costs of living with wildlife. However, we do not wish to be overly negative, we believe that returning wildlife revenues to the valley through a community-based conservation scheme could make a considerable contribution to development in the area, and could be an important component of a conservation management plan. However, it is important to note that if 'conservation' is defined as meaning 'maintaining significant populations of large mammals', restrictions on both hunting and land use would need to be implemented and enforced. A well-planned scheme does not necessarily have to have an adverse impact on local people, and if it included increased prevention of crop raiding by game scouts or through a game fence, could have a beneficial impact.

A key question in planning such schemes is what does 'conservation' actually mean – in other words 'What are the goals of conservation?' This is obviously a decision for the Tanzanian people in the area to make but we hope that this report can feed into that debate. By presenting this information on the differences in the livelihoods of the people of the Kilombero Valley, we have shown that rather than being homogenous, the communities of the valley are internally structured, with variations in livelihood strategies and levels of well-being and power. Any conservation or development programme needs to take these variations into account and to ensure that all sections of society, including pastoralists, are equitably involved in conservation or development schemes.

The final section of this report summarises the findings of each part of this survey and outlines some of the issues that should be considered when debating the future of the Kilombero Valley

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Appendix 1: The project team:

Scientists:

Project Leader	Malcolm Starkey,	
Secretary	Alison Cameron	(Aberdeen University),
Treasurer	Neil Birnie	(Edinburgh University),
	Lorraine Hood	(Aberdeen University),
	Hugo Rainey	(ex Newcastle and Reading Universities)
	Louise Haddelsey	(Aberdeen University),
	William Robinson	(Aberdeen University),
	Raphael Abdallah Daffa	(University of Dar es-Salaam),
	Joachim Makoti	(Ulanga District Forestry Dept. funded by Irish Aid)
	Ephraim Mwangomo	(University of Dar es-Salaam sponsored by WWF Tanzania),
	Nyingi Johnson	(Sokoine University of Agriculture),
	Lydia Kapapa	(University of Dar es-Salaam).
	Mary Lyimo	(African College of Wildlife Management),
	Ladislaus Kahana	(African College of Wildlife Management),

Assistant Game Officers:

Ulanga District:
Mr Kipegijie,
Mr Ngalapa,
Mr Ngwega,
Mr Lamponi.

Kilombero District:
Mr Francis Mpina

Additional volunteers:

Inge von Shayck of the Ifakara Centre, Janet Cameron of Strathclyde University, James Maynard of Wild Footprints Safaris.

Project Driver:

Hussein Said Gombe (Irish Aid Driver)

Boatmen:

Mluta T. Mluta (Selous Game Reserve), Benson (Malinyi)

Local people:

A large number of residents of the valley were employed for short periods of time as guides, askaris, and cooks. They provided valuable assistance and support throughout.

Appendix 2: Sponsors

We are extremely grateful to the following trusts, organisations, companies and individuals for their support in kind and in cash which made the project possible.

British Sponsors

Flora and Fauna International 100% fund

British Airways

The Royal Geographical Society

Endangered Wildlife Trust

Wild Heritage Trust

The Cross Trust

Robert Nicol Trust

Aberdeen Journals

Air Vice-Marshall and Mrs J.E. Allen-Jones

Ernest Kleinwort Charitable Trust

Mr C..M. Allen-Jones

Glasgow Highland Society

Aberdeen University

Tanzanian Sponsors

Irish Aid Ulanga District

The British Council Tanzania

Wildlife Conservation Society of Tanzania

WWF Tanzania

CMC Landrover Tanzania

BP Tanzania

Standard Chartered Tanzania

Intertek Testing Services Ltd.

Gilchrist Educational Trust

Regent Tanzania Ltd.

Selous Game Reserve

Appendix 3. Expedition budget

SECTION 1 - EXPEDITION SPONSORSHIP AND FUNDRAISING

Private Donations

	£
Air Vice Marshall and Mrs Allen Jones	1000
Mr Charles Allen Jones	500
Nick and Diana Evans	50
Subtotal	**£1,550**

Corporate Sponsorship

Regent Tanzania Ltd (Logistical and administrative support throughout project)	500
British Airways (Flights for UK team members)	3500
Landrover - CMC Tanzania (vehicle parts and labour)	200
Intertec Ltd (water purification equipment)	250
Standard Chartered Bank (Tanzania)	250
Aberdeen Journals	110
BP Tanzania (Fuel sponsorship)	1000
Subtotal	**£5,810**

Research Grants

Irish Aid Tanzania/Ulanga District Council (provision of Toyota Landcruiser, payment of game guard, forest officer and driver's wages; purchase of camp equipment)	5000
Selous Conservation Project (provision of boat for river counts)	1000
The British Council	2500
Flora and Fauna International	2500
The Royal Geographical Society	1500
World Wildlife Fund	1140
Tusk Force	1000
The Cross Trust	800
The Robert Nicol Trust	600
The Gilchrist Trust	600
The Lindeth Trust	500
Leicester Education Trust	400
Wild Heritage Trust	250
Glasgow Highland Society	150
Endangered Wildlife Trust	100
Subtotal	**£18, 040**

UK Team members' personal contributions/fundraising

Personal contibutions (£800 per team member)	5600
Fundraising ceilidh proceeeds	130
Subtotal	**£5, 730**

TOTAL SPONSORSHIP/FUNDS RAISED £31, 030

SECTION 2 - EXPEDITION COSTS

Pre-expedition costs

International Flights	3500
Base and satellite camp equipment	1430
Large base camp tents	525
GPSs	860
Scientific equipment	1125
Stationery	100
Books	40
Maps	80
Vehicle spare parts and repairs to WCST landrover	190
Landcruiser and driver	2000
Landrover hire from Wildlife Society of Tanzania	525
Photographic equipment and paper	350
Aerial photos	90
Freighting costs	510
Pre-expedition transport costs (UK and Tanzania)	780
Motorised boat hire for river counts	1000
Administration and visas	1015
Medical supplies	360
Research permits	1310
Insurance	385
Tanzanian drivers licences	45
Ammunition for game guards	170
Accommodation in Dar-es-Salaam/Ifakara	280
Dar-es-salaam adminstation costs, customs fees etc.	260
Dar-es-salaam food costs	300
TOTAL	**£17, 230**

Tanzanian Counterpart wages

Project botanist	410
University of Dar-es-salaam scientists	940
University of Morogoro scientist	390
Mweka Wildlife College Scientist	90
Ulanga District Game Guards	940
Itete village camp staff	560
Selous Game Reserve boatman	55
Ulanga District Forest Officer	320
Ifakara District Game Guard	60
Ifakara District River Guide	25
TOTAL	**£3, 790**

Expedition Running Costs

Vehicle repairs and labour costs	480
Vehicle fuel	2100
Camp fuel	250
Boat fuel	400
Food and supplies for expedition team	5180
Local canoe hire	90
TOTAL	**£8, 410**

Post -expedition costs

Post-expedition living costs in Dar-es-salaam	260
Vehicle repairs	190
Administration costs	120
Transport/fuel	80
UK report preparation costs (team member transport and stationery)	200
Final report printing, postage and web design costs	750
TOTAL	**£1, 600**

TOTAL EXPEDITION COST **£31, 030**

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The project involved a considerable number of people, all of whom generously dedicated their time and energy towards it, in a multitude of different ways. We are grateful to all these people, without whom the project would not have been possible. Primary thanks should go to the people of the valley, who allowed us to camp on their land, to stay at their fishing camps and who gave freely of their time for interviews and discussions.

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- Crispin Golding and the Kilombero Valley Teak Company at Kidatu for letting us use their safe and bank account for our project money.
- Bart and Inge Knols who worked at the Ifakara Centre for valuable advice on the logistics of our work, for introducing us to so many local people and for unrivalled hospitality.
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