Forest edge distance and glade types in Mount Meru Game Reserve: bird rings in the forest.

Chapter four

Summary

The aim of the study was to examine if glade size, edge effect and interior position of forest have an influence on bird species composition, abundance and diversity in Mount Meru Game Reserve.(MMGR) The study areas were three glade types: man-made, lower natural and upper natural glades with a total of 25 sampling sites. Bird total abundance, species richness and diversity decreased with edge distance into the forest interior for man-made glades and no decrease with edge distance for upper and lower natural glades. There were more shrubs at the edge of man-made glades than lower and upper natural glades. Insect eater birds were dominant at the edge of man-made glades. Forest edge habitats were much deeper into the forest of lower natural glades and less deep in man-made and upper natural glades. Bird species composition differed significantly between habitats. Glade sizes influenced bird total abundance and species richness on the forest edge of lower natural glades. Habitat guild was associated with foraging in man-made glades, but not associated with nesting, diet, and habitat in the three habitat types. It is recommended that equal priority should be given for the management of small and big sized glades, as they appear to be important habitats for birds. Rather than manage avian diversity per se, Mountain Greebul in the upper natural and Common Bulbul in man-made, glades can be indicators of forest edge and Collard Sunbird in man-made and Montane White-eye in the forest interior. These bird species can be employed as indicators of habitat changes in Mount Meru Game Reserve.

4.1. Introduction:

Habitats must not be seen in isolation in a forest that hold unique biological characteristics, ecological roles and associated species (Matlack & Litvaitis, 1999, Wunderle *et al*. 2005) such habitats impact on surrounding habitats for example edges where two habitat types meet. In general, but not always, the two habitats found flanking the edge would enhance species diversity at the edge (Sisk & Margules, 1993). In particular, edges may benefit bird species with different habitat requirements. It may include species that require specific habitat types as habitat specialist and are thus found in one

of the adjoining habitats, or habitat generalist that occur on both side of the edge (Harris, 1988, Sisk & Margoles, Murcia, 1995, Turner, 1996, Matlack & Litvaitis, 1999). Habitat edges influence different bird species in different ways; some species may increase in abundance near edge, some decrease in abundance and other may be relatively unaffected (Sisk & Margules, 1993). In addition, while edge habitat is critical for some bird species, it may also be incompatible with requirements of many interior bird species, and the proliferation of forest edges may threaten the diversity of interior bird species (Kruger & Lawes, 1997).

Glades are island of grass found in a forest and edge as habitat may affect bird's populations in the glade and forest by influencing the biotic and abiotic conditions. Edge zones become hotter, drier, and windier, and exposed to more sunlight than the forest interior because of the air heated in glades (Laurence & Vasconcelos 2004). The distance from the edge effects penetrate the forest, as do the proportional sizes of interiors and edge habitat, influence the diversity and abundance of birds to be found in this zone (Murcina, 1995). These microenvironment changes at edges may have a significant impact on the resources, e.g. increase in insect's population at the edge will attract high number of bird species to forage on them (Gutzwiller & Anderson, 1992, Murcia, 1995). The character of the edge produce mixed vegetation and changes in plant composition that also influences edge zone. The changes in plant composition and structure at edges will thus influence bird and plant distributions and density because these parameters integrate microhabitat diversity (Harris, 1988, Terborgh, 1992, Murcia, 1995, Turner, 1996, Matlack & Litvaitis, 1999, Zuidema *et al*. 2005). Edges thus become the locus for a group of bird that are dependent on the dense, shrubby growth at closed forest edge (Matlack & Litvaitis, 1999)**.** In forests, the microclimates are controlled by the crown canopy, whereas in clearings the soil is the thermodynamically active surface (Harris, 1988, Murcia, 1995, Turner, 1996, De Graaf *et al.* 1996, Zuidema *et al.* 1996, Baker *et al.* 2002.

The forest dynamics and also changes by human activities determine the changes in plant composition and structure at the forest edge. This will depend on the intensity and extent of direct human disturbances on the vegetation such as clear cutting, road building, flood control, drainage of wetland, fire control, hunting, forest clearing for agriculture and development, recreation and logging (Mucina & Geldenhuys, 2006). Therefore clearing of plants species at the edge will influence the

microhabitats of forest across the line. Air heated in the clearing often moves into the forest lowering humidity, drying leaf litter and creating drought stress for plants species. As a result, the characteristic of forest edge may change through succession time as forbs; shrubs and saplings are recruited at the edge, thus causing varied habitat types and resources at the edge, which in turn increase bird abundance and diversity (Murcia, 1995, Matlack & Litvaitis, 1999)

The conservation role of small habitat patches like glades, not only the edge distance is important, but also size of the patch (Shaw, 1985). Small areas have relatively more edge habitat with a higher population of individuals occurring near the edge. This may lead to extinction as increased herbivory; predation and reduced seed germination are found along a habitat edge of the forest (Young *et al.* 1995, Mathew *et al*. 1999). Therefore, the level of management required for each glade patch is determined by its size, the bigger the protected area the less intensive the management efforts necessary (Shaw, 1985, Sutherland, 2000, Wunderle *et al.* 2005).

Studies of glades plant communities have shown that species composition, both within glades and on the glade edge, is very different to the surrounding forest (Young *et al*. 1995). Therefore, Mount Meru Game Reserve where three glade types of different size are found in dissimilar, but adjacent habitats provides an ideal area for studying different habitat types. The area is also highly suitable for examining forest edges, glade sizes and glades types. The study was looking on the bird diversity between man-made upper and lower natural glades, as glades and their edges play an important conservation role as plant composition and structure influence the distribution and diversity of many birds, (Malcolm & Hunter, 1999).

The aims of the study were to:

1. Understand the biodiversity value, the conservation role of edges between glade and forest by examining the patterns and processes that drive the interaction between birds, glades and surrounding forests.

2. Compare glade types between avian diversity and provide management recommendation if the man-made and actively maintained edges should be managed as they are, or should the forest be allowed to re-invade the glades and restore it to its natural environment.

It was hypothesized that bird diversity and edge use will differ between man-made, upper and lower natural glades.

4.2 Materials and Methods:

4.2.1. Study habitat

The study was conducted in Mount Meru Game Reserve (MMGR) from early September 2005 to mid May, 2006. The study area was 66sq Km^2 in size with an altitude 1500-2800 meters above sea levels (masl) and is located at (03^0 16" S; 36^0 50" E) in northern Tanzania on the eastern slopes of Mount Meru (25 km from Mount Kilimanjaro) and 35km North east of Arusha town. The reserve has 33 forest glades of different types with varying size ranging from 375 to 37 694 m^2. The first type is man-made glades, the second lower natural glades and the third type is the upper natural glades. The man-made and lower natural glades are located between attitude 1400-1800 m.a.s.l and the upper natural glades located at above 2000 m.a.s.l. These glades constitute 4.8% of the area of the reserve (Fig.4 1).

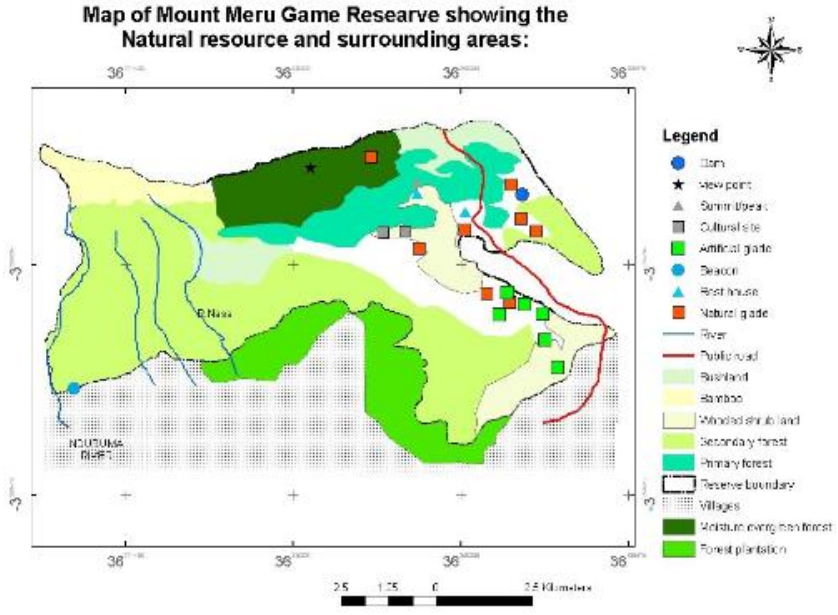

Fig 4.1. Map of Mount Meru showing the location of the study glade

4.2.2. Bird survey and analyses

The bird survey was carried out between September and November 2005. Three transects, of 10 m long and 30m wide (300 m^2) with the central line of the transect 30 m apart, located 5, 35, and 65 m were laid down in each of 25 glades sampled starting at the forest edge reaching into the forest (Fig 4.1). The transects were separated by 20 meters buffer zones to avoid double counting of avifauna. The avifauna was recorded by slowly walking at 10 meters per minute all individuals seen or heard from the forest floor to the canopy within transect were counted and recorded. Also, all the activity performed by the birds was recorded. The birds' surveys took place between 06h.00 to 10h 00 and 16h 00 to 18h 00 when birds were most active. Five visits were made to each plot surveyed. During each visit, the sequence of the survey was randomly chosen to avoid bias. Data for all activity was recorded and average mean taken. For each glade type, the species richness and total mean abundance in each transect were calculated. Shannon- weiner diversity index (H') was employed to calculate the species diversity (Krebs, 1989). For each habitat type, the total mean abundance, species richness and diversity of bird were compared (Hutto *et al.*1986). Birds were classified into feeding guilds (e.g. frugivores), nesting guilds (e.g. hole nesters), associated habitats (e.g. edge species), and Red data status (e.g. endangered) according to (Stevenson & Fanshawe, 2002). Chi–square analysis was used to test if the different user guilds were associated with various avifauna characteristics. Scientific names of species recorded followed (Stevenson & Fanshawe, 2002) and are presented in Appendix 4.1.

The Sorensen similarity index analysis was performed to compare if there is any similarity in species composition in the three habitat types, man-made, upper and lower natural glades. (Magurran, 2004). Multiple Response Permutation Procedure (MRPP) was employed to determine the bird species composition differed between the three habitat types (McCunes & Mefford, 1999). MRPP is a non-parametric procedure that evaluates the uniqueness of a group relative to all other permutations (McCune & Grace, 2002). It generates a test statistic, *T* the more negative the greater the separation between groups; a *P*-value to describe the likelihood that the difference is due to chance and a measure of effect size, *A*, which describe within group homogeneity.

A two tailed t-test was performed to compare feeding and non feeding activity (singing perching, flying, nesting, and walking for the birds.

To test for habitat selectivity for birds, Jacob's modification of Ivlev's index was used. For each species, the index produces value range from -1 to +1, where negative values are indicative of avoidance of, and positive values are indicative of selection for a particular habitat (Mclnness *et al.*2005).

An indicator species analysis was employed to detect and describe the value of species as habitat indicator (McCunes & Mefford 1999). The method combine information on relative abundance and frequency of each species in a particular habitat to produce and indicator value that ranges from zero to 100 (100 is a perfect indication).

The glade size was determined by traversing along the edges of the glades and the size of the area was calculated using track log on GPS garmin 12 channels. The proportion edge area of the forest ring and glades shape index was calculated.

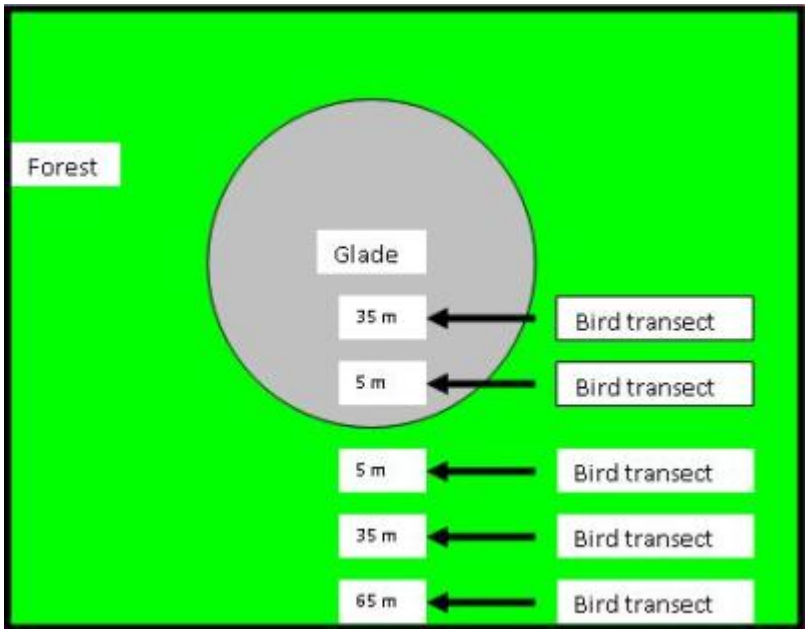

Fig. 4.1. Bird transects layout 5m, 35m and 65m from the glade edge to the forest interior and glade interior.

4.2.3. Vegetation and bird analyses

For each glade type, the species richness and total abundance in each transects were calculated. Shannon diversity index (H') was employed to calculate the species diversity. For each sampling site (Fig 4.2) on the transect 5m, 35m and 65m, the total abundance, species richness and diversity of plant species were compared according to Hutto *et al*.1986).

Correlation, regression and stepwise model analysis were performed **t**o determine which vegetation variables, total abundance, species richness, abundance and growth forms (independent) best predict bird diversity (dependent variables) in each habitat types, ANOVA was performed to compare bird total abundance, species richness and diversity within the three habitat types.

4.3 RESULTS

4.3.1. Three way comparison within habitat types

4.3.1.1. Bird species

Sixty-eight bird species were recorded in the forest interior of the three glade types and five species in the glade interior (See Appendix 4.1Out of these, ten bird species were recorded in all glade types, sixteen in man-made and lower natural glades, nine in lower and upper natural glades, thirteen in only lower natural lonely, thirteen in man-made glades only and four in upper natural glades only (Table 4.1). One threatened bird the Taveta Golden Weaver was recorded in Man-made glades.

The lower natural glades had the highest number 430 of birds, followed by upper natural with 256 and man-made glades 244. Bird species richness was higher in lower natural glades with 49 species, followed by man-made with 41 and upper natural glades 25 species. .Species diversity was higher in upper natural glades with diversity index of 0.14 and man-made and lower natural glades had proportionately equal diversity index of 0.06. The upper natural glades was the most heterogeneous habitat among the three study habitats with heterogeneity value of 0.24, lower natural 0.17 and man-made glades 0.16 (Table 4.2).

Species composition in the forest edge of the three study habitat types differed significantly between habitats, i.e. were different occupying different species space (MRPP; T = -7.71, A = 0.32, P < 0.001).

Species composition at 5 m from the forest edge differed significantly between habitat types (MRPP; T = -4.34, A = 0.20, P < 0.001), at 35 m was (MRPP; T = -2.79, A = 0.11, P < 0.001) and at 65 m was (MRPP; T = -0.82, A = 0.004, P < 0.05). The trend showed that there was a reduction in species composition with distance into the forest at 5 m, 35 m and 65 m.

The study showed that there was a significant relation between edge distances (5 m, 35 m, and 65 m) and bird indices in the three study habitats types. The total abundance and species richness were highly significant with edge distances for man-made glades and species diversity for upper and lower natural glades (Table 4.3)**.**

However, there was no correlation between edge distance and avian indices for glade birds in three study habitat types, could not differ with edge distances (Table 4.4). Bird total abundance, species richness and species diversity decreased significantly with edge distance (Table 4.5). In general, the result showed that there were more birds number, species richness and diversity on the edge of man-made glades compared to lower and upper natural glades (Fig 3-5).

Bird indices for the three habitat types showed that bird total abundance and species richness were highly significant with glade size for lower natural glades and upper natural glades for bird total abundance and species diversity, but not significant for man-made glades (Table 4.6). There was no significant difference of bird indices with glade size (Table 4.7). Bird total abundance and species richness at the forest edge was highly significant with glade size in lower natural glades (Table 4.8), but bird indices could not differ with glade size (Table 4.9).

Plant growth forms (trees, forbs, grass, shrubs and dwarf-shrubs significantly increased bird parameters (total abundance, species richness and diversity). For example an increase in plant species richness corresponded with increase in bird total abundance for upper natural glades **(**Table 4.10).

Analysis of plant against bird indices (total abundance, species richness and diversity) showed that grass total abundance increased, significantly with increased bird total abundance in the lower natural glades. Similarly, forbs total abundance significantly decreased bird total abundance and species

richness in man-made glades. Forbs percentage basal cover increased, significantly with increased bird's total abundance in upper natural glades (Table 4.11).

A disproportionably higher number of birds selected man-made habitat types (selective index >0.50), whereas almost equal proportion selected upper and lower natural glades (Fig. 2). Upper natural glades had the highest habitat avoidance (selectivity index < 0.51) followed by lower natural and man-made glades (Table 4.12).

The birds identified as indicators of environmental conditions in the three study habitats on the forest edge are listed in table 4.13. The upper natural glades had four species namely Montane White-eye, Brown Woodland Warbler, Mountain Greenbul and African Dusky Flycatcher whereas in man-made glades, four species i.e. Common Bulbul, Black-throated Wattle-eye, Chin-spot Batis, and Collard Sunbird and none for lower natural glades. Two edge interior bird species the Collard Sunbird and Montane White-eye were recorded in the forest interior from upper natural and man-made glades respectively and none for lower natural glades (Table 4.13).

A total of eight birds were identified as indicator of environmental conditions across the three transects of the three habitat types located at 5 m, 35 m and 65 m from the forest edge to the forest interior (Table 4.14). as follows in upper natural glades three bird species Mountain Greebul, Montane White-eye and African Dusky Flycatcher were recorded at the transect located 5 meters, two birds the Montane White-eye and Brown Woodland Warbler. At 35 meters and one bird Montane White-eye at 65 meters. In man-made glades three bird species Collard Sunbird, Black-backed Puffback and Common bulbul were indicator for transect located 5 meters and one bird the Grey-backed Camaroptera at 65 meters and none for lower natural glades.

Birds' similarity index analysis showed that the three habitat types were almost similar. However man-made, upper and lower natural glades were more similar with similarity index of $C_s = 0.891$, man-made and upper natural glades were slightly similar with similarity index of $C_s = 0.776$ and less similar for upper and lower natural glades with similarity index of $C_s = 0.675$.

4.3.1.2 Habitat Guild

Habitat user guild in the lower natural glades could not be associated with foraging ($X^2_8 = 1.32$, P = 0.86) and upper natural glades could not associated with foraging ($X2_6 = 3.40$, P = 0.76,), man made glades could be associate with foraging ($X^2_4 = 13.66$, P < 0.001) (Table 4.15). Habitat user guild in lower natural glades could not be associated with habitat types ($X^2_4 = 4.16$, P = 0.39), upper natural glades could not be associated with habitat types ($X^2_4 = 1.60$, P = 0.81) and man-made glades could not associated with habitat types ($X^2_4 = 0.50$, P = 0.97) (Table 4.16). Habitat user guild in lower natural glades could not be associated with nesting habitats ($X^2_8 = 2.48$, P = 0.96), upper natural glades could not be associated with habitats ($X^2_8 = 3.46$, P = 0.9) and man-made glades could not be associated with habitats ($X^2_6 = 3.65$, P = 0.72) (Table 4.17). Habitat user guild in lower natural glades could not be associated with diet ($X^2_4 = 2.94$, P = 0.94,) upper natural glades could not be associated with diet ($X2_4 = 3.39$, P = 0.76) and man-made glades could not be associated with diet ($X^2_4 = 2.83$, P = 0.86) (Table 4.18).

4.3.1.3. Bird activity

Comparison between feeding (eating) and non-feeding activity (singing, perching, hoping, nesting and walking) showed that singing was not significant at ($t_{(2)} = 2.12$, P = 0.05), perching was significant at ($t_{(2)} = 11.81$, P < 0.01), flying was significant at ($t_{(2)} = 5.25$, P < 0.05), hoping was significant at ($t_{(2)} = 8.10$, P < 0.05), nesting was significant at($t_{(2)} = 7.80$, P < 0.05), and walking was significant at ($t_{(2)} = 7.59$, P < 0.05). These activities are influenced by environment conditions with intent to exploit the resource and risk avoidance to predation.

4.4 Three way comparison between habitat types

The comparison of edge distance (5 m, 35 m, and 65 m) against forest bird indices (total abundance, species richness and diversity) in the three study habitat types (Table 4.19) showed that total abundance and species richness were highly significant for man-made glades and could not differ significantly in the three study habitats (Table 4.20).

The comparisons of bird diversity and vegetation indices for the three study habitats showed that edge distance were negatively correlated with bird total abundance, bird species richness, tree species richness, percentage shrub cover, shrub species richness, forbs species richness, edge birds, forest habitat users, forest edge habitat, nectar feeder, insect eater, fruit eater and seed eater in

man-made glades. Insect eater accounted 78%, shrub cover accounted 10% and tree species richness accounted 5% (Table 4.21). Lower natural glades, edge distance were negatively correlated with bird species diversity, dwarf-shrub species richness, interior birds and forest edge habitats. Forest edge habitat accounted for 14% (Table 4.21). However, upper natural glades, no variable were entered in the stepwise regression model.

4.5. Glade name, size, edge area and shape index.

The proportion edge area of the ring was 0.36 Km^2 of the total area of Mount Meru Game Reserve and the core area (interior part of the forest) was 65.64 Km^2 (Table 4.22). The names of glades and their shape index ranged from 0.06 to 1.00, which indicated that glades were of long narrow to sphere shaped (Table 4. 23).

4.4. DISCUSSION

4.4.1. Birds in Glades

The non significant occurrence of five non-granivorous bird species (African Citril, Green Sandpiper, Egyptian Goose, Black Stork and Black-and-white Mannikin) within and among all habitat types was a surprise because I expected to find many granivorous bird species in the glades and variation among the glades. African Citril and Black-and-white Mannikin were not seen in big flocks in the glades. Possibly because all glade types were too small in size ranging from 1,102 m^2 to 32,344 m^2 for man-made glades, 2,282 m^2 to 26,524 m^2 for lower natural and 2,068 m^2 to 13,108 m^2 for the upper natural glades. Therefore, size of the glades could be a determining factor for not accommodating big flocks of grain eater birds due to limited food resources in the glades. The limitation of resources could also be influenced by the fact that during the study period most of the grasses species were starting to flower and no seeds were available for the birds. The second factor that may have influenced avian not using the glades in MMGR is that the reserve is located in the same ecosystem with Arusha National Park. The Arusha National Park has many sites of open grassland, most of them located on the wooded shrubs, with slightly warmer temperatures. Consequently influence early maturity of grasses to provide grains for the birds and hence refugee site for grainvorous birds. So the availability of food resources in these habitats closer to MMGR influences habitat choice by grain eater birds to select habitats that provide them with sufficient food to eat. The results contradicts

with optimal foraging theory by (Sinclair *et al* 2006) which predicts that when resources are not limiting, species concentrate their feeding on the best types of food or the best type of habitat and ignore the others no matter how abundant they are, but for this case availability of food influenced habitat choice.

Glades number 9 and 10 were swampy, thus attracting birds like Egyptian Goose, Green Sandpiper and Black Stock. Egyptian Goose being grazers, the trimming actions on grasses vegetation kept the grass height level low, which deter the plants to grow to its maturity age and no seed production for grain eater birds, as a result becomes a limiting factor for glade use by seed eater birds.

4.4.2. Edge distance

The higher concentration of bird total abundance, species richness and diversity at the edge of the man-made glades than in the other upper and lower natural glade types possibly was brought about by vegetation interspersion i.e. the presence and mixture of high amount of more forbs, shrubs and fewer trees at the edge of man-made glades. This in turn provides variety of habitat that provides food for the edge bird's species. Human disturbance at the forest edge of man-made glades is a result of active management practices used to maintain the glades through slashing of shrubs, forbs and trees that are invading the glades. These changes at the edge leads to the secondary responses in the forest structure by the development of a "side wall" of dense vegetation such as shrubs, and forbs that fill in open space at edge. The character of the edge vegetation attracted insect eater birds like Green-backed Twin spot and Black-and-white Mannkin at the edge and fruit eater bird like the Common bulbul and nectar eaters like Olive and Collard Sunbirds to the edge. Edge habitats become the locus of this group of birds that are dependent on dense, shrubby growth and forbs that provide them with food to eat. This phenomenon of groups of birds to concentrate at the edge zone created bird rings at the edge and was also reported by (Kruger & Lawes 1997, Song & Hannon 1999, Harper *et al*. 2005, Cardona *et al.* 2006). They noted that species distribution and abundance is more of typical environmental disturbance.

The occupancy of more interior birds in upper and lower natural glades compared to forest edge birds' species in man-made glades and increase of species diversity with distance into the forest

interior in the lower natural glades was due to little difference in vegetation structure at the edge compared to the interior. These habitats represent a slightly more stable community than the edge. Therefore, attract more interior bird's feeder like Little Greenbul, Caban's Greenbul and Evergreen Forest Warbler into the forest. Upper natural was more heterogeneous compared to lower natural. The vegetation structure changed as you move into the forest interior, partly because of lack of active management practice at the edges and location of the glades. It was observed that species diversity in the upper natural glades increased with edge distance into the forest, because of location of the glades as they occur at higher attitudes and topographical structure of the area. This has an influence on the variety of habitat niche to be formed, as a result of different vegetation structure and composition in the forest interior, where there is no active human disturbance.

4.4.3. Glade size

In this study it was observed that glade size influenced bird mean total abundance and species richness for the upper and lower natural glades and had no influence for man-made glades. The birds used small or big sized glades interchangeably. This phenomenon is attributed by the fact that MMGR forest glades are found in forest matrix of a continuous forest connected to both small and big sized glades. Bird movement from one glade to another is easily facilitated. Therefore the question of glade size is not applicable in this context as described in the theory of Island Biogeography by (MacArthur and Willison, 1967). However this is contrary to studies on size of nature reserve by (Gotmark & Thorell 2002, Laurence & Vasconcelos, 2004) which indicated that habitat patches that are large and or close to another patch will support population of species most of the time while small or isolated forest patch will often be unoccupied. This is because species are sensitive to changes in the spatial structure of its habitat **(**National Environmental Programme, 1995**).** Relationships exist between species diversity and area. Larger areas support more species than smaller areas (Smith, 1992)

4.4.4. Environmental indicator birds

Environment indicator birds (EIB) are birds which frequent and abundant in the area (McCune & Mefford 199) and may be used to suggest the effects of change within a system at a particular scale, or to indicate population trends that results from altered ecological processes. Change in the indicator species could suggest a problem before it is too late to rectify (Thompson & Angelstam, 1999). Most

of the birds Montane White-eye, Mountain Greebul, Brown Woodland warbler and African Dusky Flycatcher; that were observed in the upper natural forest edge are of small body size, regarded as fine-grained indicator species that select habitat at small scale and therefore indicator of undisturbed habitat of MMGR forest. Common Bulbul, Collard Sunbird, Black-throated Wattle-eye and Chinspot Batis. Were predominately found in the forest edge of man-made glades because of active mangement practice used to maintain these glades at MMGR, which in turn results in increased growth of shrubs, forbs and fewer trees at the edge. The outcome of these phenomena is more of aerial insectivore birds attracted at the edge habitat resulting in the formation of bird rings at the edge. Montane White-eye and Collard Sunbird are indicators of both forest edge and interior of the upper and man-made glades. These two species of birds are habitat generalist that can exploit resources found in both of adjoining habitat (edge and interior forest), may not be affected by forest edge. However if edge vegetation is more productive than the surrounding habitat, these species may concentrate their activity at the edge (Murcia, 1995, Matlack & Litvaitis 1999). The conservation value of these indicator birds is important for giving alarm on any changes taking place in specific habitat types, whether the habitat is progressively becoming disturbed or undisturbed. Therefore forest edges are important for most common species of birds found in MMGR and threatened species like Taveta Golden Weaver. It is worthwhile to maintain edge habitat for biodiversity conservation and ecotourism in the area.

Interestingly, no indicator species was found in the lower natural glades probably because of the habitat being more homogeneous from the forest edge to the forest interior and possibly the area is used as a stop over to other habitats like upper natural glades that possesses complex structure of the community to create potential niches for birds and the man-made glades which has complex structure at the edge due to active management practice in the area, which favour avian to use it. This phenomenon was also observed by (Smith, 1992).

4.4.5 Habitat selectivity

Highest number of birds selected man-made glades habitat compared to lower and upper natural glades. The possible reason could be due to food abundance on the edge and complex structure arising from active management practices used in the area through vegetation clearing at the forest

edge of man-made glades. This results in increased shrubs, foraging material and nesting facilities for the birds due to physical obstruction on the edge. Birds selected lower natural than upper natural glades. The upper natural glade was the most avoided habitat type because of changes in topography and low temperature and food necessary for birds is limited because of short growing season for physiological maintenance. Upper natural glades are located at high attitude of 2000 meters above sea level compared to lower and man-made glades. Temperatures are moderate warmer in the man-made and lower natural glades than in the upper natural glades that in turn affect vegetation structure and composition and hence better food and increased food availability, also were reported by (Cooperider *et al* 1986, Sinclair *et al* 2006).

4.4.6 Habitat guilds

The habitat guilds could be associated with foraging in man-made glades (aerial foragers, low substratum foragers and mixed stratum foragers) but could not be associated with foraging in upper and lower natural glades. Foraging preference in man-made glades was most common on the edge with 45.9%, 36.1% mid and 18% interior. Aerial foragers were the most dominant species with 49.2% as most were insectivore which prefers to feed on the edge. It should be noted that the distribution of resources base decreased with edge distances into the forest. The birds may have been attracted to the edge due to the changes of forest structure because of active management practice in the reserve along the forest edges of man-made glades. This enabled the birds to have greater visibility vicinity at the edge as predator avoidance strategy (Paton, 1993, Murcia, 1995, Baker *et.al*.2002).

4.4.7. Implication for Conservation

The study envisaged that man-made glade edges are important habitat for variety of bird species, including all common bird species as well as threatened species like Taveta Golden Weaver and migratory species like Common Buzzard. It is also, dominated by insect eater birds and has a variety of habitat types compared to lower and upper natural glades because of active mangement practice, thus harbouring a big number of bird's species at the edge forming what is called bird rongs phenomena at the edge. It is important to maintain this area as its now for biodiversity conservation and achieving the management objective of MMGR (Now Arusha National Park) for ecotourism purposes, research and training.

Also the study has envisaged the need to use indicator species for monitoring changes that are taking place in protected areas in Tanzania. The use of indicator species can be easily understood by communities living adjacent to protected areas, if proper knowledge and skill is disseminated to them properly. It is less costly compared with other methods that require money and time to accomplish them. Therefore from management point of view, management of protected areas should adopt the use of indicator species in managing the wildlife resources. Most protected areas are currently under threat because of human population increases and their activity. Being the case and limited resources for managing these protected areas and unable to undertake applied research in time for management purposes and difficult to disseminate the results to the public in a clear and well understandable language, it's worthwhile to use indicator species. Because animal species integrate structure and processes within ecosystem at various scales depending on their body size and so by their presence can indicate the status of those structure and process to assess the effects, magnitude and mitigate the changes to the best extent possible (Thompson & Angelstam 1999). Although the methods has limitation in use, in case of having more than one indicator species in the area and one disappears, it becomes difficult to make management decision on what should be done in case of the threat, but combined by ecosystem management practices proper management decisions can be made. As indicated by the results, edge habitat appeared to be the most used habitat types by avian species for various activities. It is recommended that the current management practices employed in the area should continue. This will enhance the National Park objectives of ecotourism (such as bird watching) in a close glace at the glade and forest edges and conservation of biodiversity resources.

5.0. Conclusion and Recommendations.

Man-made glade forest edges are important habitat for variety of bird species and have a variety of habitat types compared to lower and upper natural glades because of the current active human mangement practices. Also the study has envisage the need to use indicators species for monitoring changes that are taking place in protected areas in Tanzania. The use of indicator species can easily be understood by communities living adjacent to protected areas, if proper knowledge and skill is disseminated to them properly. Based on these findings we recommend the following:

1. Continue managing MMGE man-made glades as there are currently managed.

2. The current mangement practices employed in managing MMGR should continue
3. It is important to maintain this area as its now for biodiversity conservation and achieving the mangement objectives of MMGR
4. Mangement of protected area should adopt the use of indicator species in managing the wildlife resources.

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Table 4.1. Comparison of bird distribution in the three-habitat types man-made (mm), upper natural (un) and lower natural (ln) glades.

Species found in all three habitat types			
Species	**MM**	**LN**	**UN**
Olive Sunbird	7	53	16
Hartlaub's Turaco	7	3	22
White-starred Robin	4	27	12
African Dusky Flycatcher	1	12	12
Striped-cheeked Greenbul	10	42	17
African Hill-Babbler	4	2	8
Black-backed puffback	7	9	1
Common Bulbul	25	10	1
Cabanis's Greenbul	12	7	12
African Paradise Flycatcher	2	5	1
Total number	79	170	102
Total %	**14.9**		

Species found only in man-made and lower natural glades		
Species	**MM**	**LN**
Collared Sunbird	37	44
Grey-backed Camaroptera	21	25
Forest Batis	5	5
Black-headed Oriole	1	4
Chin-spot Batis	8	1
Black-headed Apalis	2	8
Black-throated Wattle-eye	9	1
African Green-pigeon	1	1
Green-backed Twinspot	1	16
Black-and-white Mannkin	22	10
Little Greenbul	4	5
Tropical Boubou	2	2
Ruppell's Robin-chat	1	6
White-eared Barbet	13	25
White-eyed Slaty Flycatcher	3	7
Silvery-cheeked Hornbill	1	5
Total number	131	165
Total %	**23.9**	

Species found only in lower and upper natural glades		
Species	**LN**	**UN**
Montane White-eye	19	83
Brown Woodland Warbler	5	24
Black-capped Apalis	9	5
Lemon Dove	20	2
Bar-tailed Trogon	1	2
Bar-throated Apalis	4	4
Evergreen Forest Warbler	2	5
Mountain Greenbul	5	23
Olive Woodpecker	1	1
Total number	66	149

Total %	**13.4**	

Species found only in man-made and upper natural glades		
Species	**MM**	**UN**
Kenrick's Starling	2	2
Yellow-breasted Apalis	1	2
Total number	**3**	**4**
Total %	**3**	

Species found only in man-made glades (unique)	
Black Saw-wing	3
Speckled Mousebird	7
Black Cuckoo-shrike	1
Common Stonechat	1
Common Waxbill	2
Taveta Golden Weaver	4
Trilling Cisticola	6
Brown-crowned Tchagra	1
Brown-breasted Barbet	1
Variable Sunbird	1
Yellowbill Coucal	1
Cape Robin-chat	2
Mountain Yellow Warbler	1
Total number	**31**
Total %	**19.4**

Species found only in upper natural glades (unique)	
Thick-billed Seedeater	3
Abbyssinian Crimsowing	2
Montane Thrush	1
African Wood Owl	1
Total number	**7**
Total %	**6**

Species found only in lower natural glades (unique)	
Moustached Green Tinkerbird	1
Grey-headed Negrofinch	1
Black-fronted Bush-shrike	7
Common Buzzard	1
Lesser Honeyguide	1
Scaly Francolin	1
Blue-mantled Creasted-flycatcher	2
Scaly-throated Honeyguide	1
Crowned Hornbill	3
African Emerard Cuckoo	1
Red-headed Weaver	2
Red-chested Cuckoo	2
Amethyst Sunbird	1
Total number	**24**
Total %	**19.4**

Table 4.2 Summary of bird total abundance, richness and diversity indices recorded in the three habitats types.

Bird variables	Man-made	Lower natural	Upper natural
Total abundance	244	430	256
Species richness	41	49	25
Diversity (H")	0.06	0.06	0.14
Homogeneity	0.84	0.83	0.76
Heterogeneity	0.16	0.17	0.24
Unique species	13	13	4

Table 4.3. Three-way comparison of edge distances against bird variables within the three habitat types for forest birds.

Glade type	Bird variables	Distances (m)			ANOVA $F_{(2,12)}$
		5	35	65	
Man-made	Total abundance	5.24 ± 2.14	3.36 ± 1.30	1.16 ± 1.73	6.77***
	Species richness	9.40 ± 3.36	6.80 ± 1.64	2.20 ± 2.1.92	11.27***
	Species diversity	0.03 ± 0.02	0.05 ± 0.03	0.09 ± 0.13	0.78
Upper natural	Total abundance	3.56 ± 1.62	3.36 ± 1.52	3.56 ± 2.02	0.02
	Species richness	6.20 ± 3.19	6.60 ± 3.36	6.20 ± 1.92	0.03
	Species diversity	0.07 ± 0.05	0.04 ± 0.03	0.31 ± 0.06	50.13***
Lower natural	Total abundance	2.04 ± 1.82	2.21 ± 2.21	1.44 ± 1.90	0.69
	Species richness	4.67 ± 2.32	4.33 ± 2.64	3.60 ± 2.80	0.65
	Species diversity	0.04 ± 0.02	0.06 ± 0.04	0.19 ± 0.16	10.75***

***P < 0.001

Table 4.4. Three-way comparison of edge distances against bird variables within the three habitat types for glade interior birds.

Glade type	Bird variables	Distances (m)			ANOVA $F_{(2,12)}$
		5	35	65	
Man-made	Total abundance	0.00 ± 0.00	1.20 ± 2.68	0.00 ± 0.00	1.00
	Species richness	0.00 ± 0.00	0.20 ± 0.45	0.00 ± 0.00	1.00
	Species diversity	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	-
Upper natural	Total abundance	1.50 ± 3.00	0.00 ± 0.00	0.00 ± 0.00	1.00
	Species richness	0.25 ± 0.50	0.00 ± 0.00	0.00 ± 0.00	1.00
	Species diversity	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	-
Lower natural	Total abundance	0.00 ± 0.00	1.33 ± 3.60	0.00 ± 0.00	2.06
	Species richness	0.00 ± 0.00	0.33 ± 0.90	0.00 ± 0.00	2.06
	Species diversity	0.00 ± 0.00	0.11 ± 0.29	0.00 ± 0.00	2.11

Table 4.5. Relationship between glade types edge distances against different bird parameters in the three habitat types.

Glade type	Bird variables	Regression	
		$F_{(1,43)}$	R^2
Lower natural	Total abundance	0.76	-0.02
	Species richness	1.30	-0.03
	Species diversity	2.96	-0.06
		$F_{(1,13)}$	R^2
Upper natural	Total abundance	0.00	0.00
	Species richness	0.00	0.00
	Species diversity	0.08	0.06
		$F_{(1,13)}$	R^2
Man-made	Total abundance	14.60***	-0.53
	Species richness	22.73***	-064
	Species diversity	18.56***	-0.59

***P<0.001

Table 4.6. Variations of bird total abundance, diversity and species richness observed among glade size in the three study habitats.

Glade type	Avian variables	Glade size (m^2)	Mean and SD	$F_{(4,10)}$
Lower natural	Total abundance	2282	3.33 ± 2.08	10.22***
		3345	32.67 ± 7.51	
		3453	5.33 ± 2.52	
		3568	5.67 ± 5.51	
		5667	8.00 ± 6.08	
		6092	7.00 ± 2.00	
		6403	3.67 ± 4.04	
		7679	4.00 ± 1.72	
		7733	9.67 ± 2.08	
		8240	25.67 ± 9.61	
		9463	16.00 ± 6.56	
		17795	5.33 ± 1.53	
		26524	8.33 ± 3.51	
		32835	4.00 ± 3.61	
		33309	3.67 ± 3.22	
	Species richness	2282	2.00 ± 1.00	3.90***
		3345	8.33 ± 2.08	
		3453	4.00 ± 2.65	
		3568	2.67 ± 2.08	
		5667	3.33± 2.08	
		6092	4.33 ± 1.53	
		6403	2.33 ± 2.52	
		7679	2.33 ± 0.58	
		7733	5.00 ± 0.00	
		8240	9.00 ± 1.00	
		9463	5.67± 0.58	
		17795	3.67 ± 1.16	
		26524	4.67 ± 2.08	

		32835	3.33 ± 3.22	
		33309	2.33 ± 2.08	
	Species diversity	2282	0.70 ± 0.60	1.71
		3345	1.81 ± 0.22	
		3453	1.16 ± 0.66	
		3568	0.73 ± 0.78	
		5667	0.92 ± 0.79	
		6092	1.31 ± 0.37	
		6403	0.73 ± 0.78	
		7679	0.76 ± 0.22	
		7733	1.52 ± 0.07	
		8240	1.88 ± 0.08	
		9463	1.48 ± 0.11	
		17795	1.21 ± 0.29	
		26524	1.35 ± 0.42	
		32835	0.85 ± 0.97	
		33309	0.64 ± 0.62	
Upper natural	Total abundance	2060	25.00 ± 7.81	4.33*
		2975	11.67 ± 3.50	
		3037	16.00 ± 3.51	
		3239	24.33 ± 7.37	
		13108	10.33 ± 4.93	
	Species richness	2060	7.33 ± 2.31	3.09
		2975	4.67 ± 1.53	
		3037	5.33 ± 2.08	
		3239	9.67 ± 1.16	
		13108	4.67 ± 3.06	
	Species diversity	2060	1.77 ± 0.15	5.84**
		2975	0.50 ± 0.87	
		3 037	1.21 ± 0.43	
		3 239	2.05 + 0.20	
		13 108	0.60 ± 0.45	
Man-made	Total abundance	1 102	14.67 ± 11.85	0.87
		9 876	9.67 ± 5.51	
		11 677	26.67 ± 7.37	
		21 405	12.67 ± 13.43	
		32 344	17.67 ± 18.01	
	Species richness	1 102	5.67 ± 4.16	0.24
		9 876	4.67 ± 2.08	
		11 677	8.00 ± 3.00	
		21 405	6.33 ± 5.86	
		32 344	6.00 ± 5.29	
	Species diversity	1 102	1.14 ± 1.02	0.20
		9 876	1.28 ± 0.38	
		11 677	1.72 ± 0.38	
		21 405	1.44 ± 0.84	
		32 344	1.38 ± 1.21	

*P < 0.05, ***P < 0.001

Table 4.7. Relationship between glade size and bird variables in the three study habitats.

Glade types	Bird variables	Regression	
		$F_{(1,43)}$	R^2
Lower natural	Total abundance	2.70	-0.06
	Species richness	0.88	-0.02
	Species diversity	0.77	-0.02
		$F_{(1,13)}$	R^2
Upper natural	Total abundance	3.97	-0.23
	Species richness	1.45	-0.10
	Species diversity	3.01	-0.19
		$F_{(1,13)}$	R^2
Man-made	Total abundance	0.02	0.00
	Species richness	0.02	0.00
	Species diversity	0.09	-0.01

Table 4.8. Relationship between glade sizes against forest edge avian variables within the three habitat types.

Glade types	Bird variables	ANOVA
		$F_{(2,13)}$
Lower natural	Total abundance	11.52***
	Species richness	4.83***
	Species diversity	0.72
Upper natural	Total abundance	0.04
	Species richness	0.04
	Species diversity	0.88
Man-made	Total abundance	0.98
	Species richness	0.45
	Species diversity	0.49

Table 4.9. Relationship between glade type sizes against forest edge bird variables in the three-study habitat types.

Glade types	Bird variables parameters	Regression	
		$F_{(1,43)}$	R^2
Lower natural	Total abundance	2.11	-0.07
	Species richness	0.53	-0.02
	Species diversity	0.04	-0.04
Upper natural	Total abundance	1.45	-0.15
	Species richness	0.51	-0.06
	Species diversity	0.23	0.03
Man-made	Total abundance	0.22	0.03
	Species richness	0.32	0.04
	Species diversity	0.16	0.02

Table 4.10. Comparison between plants against bird variables in the three study habitats.

Glade type	Plant variables	Bird variables parameters	$F_{(1,13)}$	R^2
Man-made	Total abundance	Total abundance	0.137	-0.011
		Species richness	0.247	-0.019
		Species diversity	0.562	-0.041
	Basal cover	Total abundance	0.533	-0.039
		Species richness	1.989	-0.133
		Species diversity	1.620	-0.111
	Canopy cover	Total abundance	2.164	-0.143
		Species richness	0.783	-0.057
		Species diversity	0.047	0.004
	Species richness	Total abundance	1.618	0.111
		Species richness	0.487	0.036
		Species diversity	0.001	0.000
	Species diversity	Total abundance	0.374	0.028
		Species richness	0.384	0.029
		Species diversity	0.075	0.006
Upper natural	Total abundance	Total abundance	0.156	-0.012
		Species richness	1.277	0.089
		Species diversity	0.014	-0.001
	Basal cover	Total abundance	0.051	0.004
		Species richness	0.290	0.022
		Species diversity	0.109	0.008
	Canopy cover	Total abundance	0.150	0.011
		Species richness	0.042	-0.003
		Species diversity	0.018	0.001
	Species richness	Total abundance	5.720*	0.306
		Species richness	3.274	0.201
		Species diversity	1.453	-0.101
	Species diversity	Total abundance	1.984	0.132
		Species richness	0.000	0.000
		Species diversity	0.278	0.021
Glade type	**Plant variables**	**Bird variables**	**$F_{(1,43)}$**	**R^2**
Lower natural	Total abundance	Total abundance	1.812	0.040
		Species richness	0.245	0.006
		Species diversity	0.136	0.003
	Basal cover	Total abundance	0.004	0.000
		Species richness	0.663	-0.015
		Species diversity	0.117	-0.003
	Canopy cover	Total abundance	1.019	-0.023
		Species richness	1.495	-0.034
		Species diversity	1.086	0.025
	Species richness	Total abundance	0.404	-0.009
		Species richness	0.030	-0.001
		Species diversity	0.467	-0.011
	Species diversity	Total abundance	0.026	-0.001
		Species richness	0.096	0.002
		Species diversity	0.813	0.019

*P<0.05

Table 4.11. Comparison between plant growth forms against bird variables in the three study habitats.

Glade types	Plant variables	Avian variables	Regression $F_{(1,43)}$	R^2
Lower natural	Trees total abundance	Total abundance	3.750	0.080
		Species richness	1.285	0.029
		Species diversity	0.246	0.006
	Tree % canopy cover	Total abundance	0.004	0.000
		Species richness	0.148	0.003
		Species diversity	0.212	0.005
	Tree species richness	Total abundance	1.041	0.024
		Species richness	0.195	0.005
		Species diversity	0.037	0.001
	Forbs total abundance	Total abundance	1.729	0.039
		Species richness	0.330	0.008
		Species diversity	0.000	0.000
	Forbs % basal cover	Total abundance	1.143	0.026
		Species richness	0.232	0.005
		Species diversity	0.271	-0.006
	Forbs species richness	Total abundance	0.435	0.010
		Species richness	0.407	0.009
		Species diversity	0.014	0.001
	Grass total abundance	Total abundance	4.499*	0.095
		Species richness	1.554	0.035
		Species diversity	0.141	-0.003
	Grass % basal cover	Total abundance	0.601	0.014
		Species richness	0.014	0.000
		Species diversity	0.018	0.000
	Grass species richness	Total abundance	0.391	0.009
		Species richness	0.422	0.010
		Species diversity	0.093	0.002
	Shrub total abundance	Total abundance	0.025	-0.001
		Species richness	0.000	0.000
		Species diversity	0.327	-0.014
	Shrub % basal cover	Total abundance	0.085	-0.004
		Species richness	0.001	0.000
		Species diversity	0.650	-0.027
	Shrub species richness	Total abundance	0.396	0.017
		Species richness	0.327	0.014
		Species diversity	0.520	-0.022
	Dwarf-shrub total abundance	Total abundance	0.384	0.018
		Species richness	0.833	0.038
		Species diversity	0.020	0.001
	Dwarf-shrub % basal cover	Total abundance	0.032	0.002
		Species richness	0.215	0.010
		Species diversity	0.001	0.000
	Dwarf-shrub species richness	Total abundance	2.831	0.119
		Species richness	0.789	0.036
		Species diversity	1.076	0.049
Man-made	Forbs total abundance	Total abundance	4.741**	-0.267
		Species richness	5.026*	-0.278
		Species diversity	0.000	0.000

	Forbs % basal cover	Total abundance	4.322	0.250
		Species richness	3.717	0.222
		Species diversity	0.001	0.000
	Forbs species richness	Total abundance	2.006	0.134
		Species richness	1.020	0.073
		Species diversity	1.051	0.004
	Grass total abundance	Total abundance	0.661	0.048
		Species richness	0.404	0.030
		Species diversity	0.000	0.000
	Grass % basal cover	Total abundance	0.012	-0.001
		Species richness	0.067	0.005
		Species diversity	0.006	0.000
	Grass species richness	Total abundance	0.178	-0.014
		Species richness	0.490	0.032
		Species diversity	1.442	-0.100
	Shrub total abundance	Total abundance	0.179	0.014
		Species richness	1.948	0.130
		Species diversity	0.061	-0.005
	Shrub % basal cover	Total abundance	0.267	0.020
		Species richness	2.118	0.140
		Species diversity	0.117	-0.009
	Shrub species richness	Total abundance	0.014	0.001
		Species richness	0.825	0.060
		Species diversity	0.049	-0.004
	Dwarf-shrub total abundance	Total abundance	0.008	0.001
		Species richness	0.291	0.022
		Species diversity	0.037	0.003
	Dwarf-shrub % Basal cover	Total abundance	0.338	0.025
		Species richness	0.000	0.000
		Species diversity	0.117	0.009
	Dwarf-shrub species richness	Total abundance	0.010	0.001
		Species richness	0.181	0.014
		Species diversity	0.022	0.002
Upper natural	Tree total abundance	Total abundance	0.365	0.027
		Species richness	0.005	0.00
		Species diversity	0.611	0.045
	Tree % canopy cover	Total abundance	0.127	-0.010
		Species richness	0.847	-0.061
		Species diversity	0.127	0.010
	Tree species richness	Total abundance	1.989	-0.133
		Species richness	0.774	-0.056
		Species diversity	0.244	0.018
	Forbs total abundance	Total abundance	3.798	0.240
		Species richness	3.797	0.240
		Species diversity	0.77	0.006
	Forbs % basal cover	Total abundance	4.685**	0.281
		Species richness	4.471	0.271
		Species diversity	0.009	0.001
	Forbs species richness	Total abundance	1.355	0.101
		Species richness	0.471	0.038
		Species diversity	0.158	-0.012
	Grass total abundance	Total abundance	0.456	0.034
		Species richness	0.140	-0.011

	Species diversity	0.276	0.021
Grass % basal cover	Total abundance	0.137	0.010
	Species richness	0.266	-0.020
	Species diversity	0.155	0.012
Grass species richness	Total abundance	1.580	0.108
	Species richness	0.319	0.024
	Species diversity	0.066	0.005
Shrub total abundance	Total abundance	0.072.	0.005
	Species richness	0.392	-0.029
	Species diversity	0.795	-0.058
Shrub % basal cover	Total abundance	0.133	0.010
	Species richness	0.022	-0.002
	Species diversity	0.474	-0.035
Shrub species richness	Total abundance	1.333	0.093
	Species richness	0.869	0.063
	Species diversity	0.288	-0.022
Dwarf-shrub total abundance	Total abundance	0.097	-0.007
	Species richness	1.731	-0.117
	Species diversity	0.158	0.012
Dwarf-shrub % basal cover	Total abundance	0.097	-0.007
	Species richness	1.731	-0.117
	Species diversity	0.158	-0.012
Dwarf shrub species richness	Total abundance	0.097	-0.007
	Species richness	1.731	-0.117
	Species diversity	0.158	-0.012

*P < 0.05; **P < 0.01

Table 4.12. Site selection, based on Ivlev's index, of birds identified in the three habitats. Values:-1 indicates avoidance for a particular site; + 1 indicates selection of a particular site and 0 no preference.

Species	Man-made	Upper natural	Lower natural
Collared Sunbird	0.67	-1.00	-0.31
Olive Sunbird	-0.42	0.03	0.22
Forest Batis	0.48	-1.00	-0.03
Hartlaub's Turaco	1.00	0.80	-0.87
White-starred Robin	-0.39	0.26	0.00
Moustached Green Tinkerbird	-1.00	-1.00	1.00
Montane White-eye	-1.00	0.88	-0.71
African Dusky Flycatcher	-0.67	0.68	-0.42
Brown Woodland Warbler	-1.00	0.90	-0.76
Grey- headed Negrofinch	-1.00	-1.00	1.00
Grey-backed Camaroptera	0.59	-1.00	-0.17
African Black-headed Oriole	0.00	-1.00	0.46
Black-capped Apalis	-1.00	0.74	-0.43
Black Saw-wing	1.00	-1.00	-1.00
Black-headed Apalis	0.00	-1.00	0.46
Black-throated Wattle-eye	0.95	-1.00	-0.86
Striped-cheeked Greenbul	-0.02	0.32	0.49
Speckled Mousebird	1.00	-1.00	-1.00

Chin-spot Batis	0.94	-1.00	-0.85
African Hill-babbler	0.23	0.68	-0.80
Green-backed Twinsspot	-0.97	-0.46	-0.48
Black Cuckoo-shrike	1.00	-1.00	-1.00
Black-fronted Bush-shrike	-1.00	-1.00	1.00
Black-backed Puffback	0.47	-0.60	-0.14
Black-and-white Mannikin	0.80	-1.00	-0.54
Lemon Dove	-1.00	-0.43	0.74
Little Greenbul	0.52	-1.00	-0.05
Kenrick's Starling	0.60	0.60	-1.00
Tropical Boubou	0.60	-1.00	-0.20
Ruppel's Robin-chat	-0.27	-1.00	0.78
Common Bulbul	0.87	-0.77	-0.73
Common Stonechat	1.00	-1.00	-1.00
Common Waxbill	1.00	-1.00	-1.00
Cabani's Greenbul	0.43	0.43	-0.67
Taveta Golden Weaver	1.00	-1.00	-1.00
Trilling Cisticola	1.00	-1.00	-1.00
Thick-billed Seedeater	-1.00	1.00	-1.00
Bar-tailed Trogon	-1.00	0.78	-0.50
Bar-throated Apalis	-1.00	0.60	-0.20
Brown-crown Tchagra	1.00	-1.00	-1.00
Brown-breasted Barbet	1.00	-1.00	-1.00
White-eared Barbet	0.35	-1.00	0.16
White-eyed slaty Flycatcher	0.33	-1.00	0.14
Common Buzzard	-1.00	-1.00	1.00
Yellow-breasted Apalis	0.33	0.78	-1.00
African Paradise-flycatcher	0.14	-0.27	0.05
Lesser Honeyguide	-1.00	-1.00	1.67
Evergreen Forest Warbler	-1.00	0.82	-0.58
Mountain Greenbul	-1.00	0.90	-0.75
Scaly Francolin	-1.00	-1.00	1.00
Olive Woodpecker	-1.00	0.60	-0.20
Variable Sunbird	1.00	-1.00	-1.00
Abbysinica Crimsonwing	-1.00	1.00	-1.00
Yellowbill Coucal	1.00	-1.00	-1.00
Blue mantled crested Flycatcher	-1.00	-1.00	1.00
Cape Robin-chat	1.00	-1.00	-1.00
Scaly-throated Honeyguide	-1.00	-1.00	1.00
Montane thrush	-1.00	1.00	-1.00
Mountain Yellow Warbler	1.00	-1.00	-1.00
Crowned Hornbill	-1.00	-1.00	1.00
African Emerald Cuckoo	-1.00	-1.00	1.00
African Green-pigeon	0.60	-1.00	-0.20
Red-headed Weaver	-1.00	-1.00	1.00
Silvery cheeked Hornbill	-0.01	-1.00	0.54
Amethyst Sunbird	-1.00	-1.00	1.00
African Wood Owl	-1.00	1.00	-1.00
Red-chested Cuckoo	-1.00	-1.00	1.00

Table 4.13. The foraging preference of avifauna in lower natural, upper natural and man-made glades habitats.

		Foraging substratum			
		Aerial foraging substratum	**Ground and Grass(low substratum)**	**Mixed foraging substratum**	**Total (%)**
Lower natural	Edge	19	12	2	33 (36.2)
	Mid	19	7	2	28 (30.8)
	interior	19	10	1	30 (33
	Total	57 (62.6)	29 (31.9)	5 (5.5)	91
Upper natural	Edge	12	6		18 (32.7)
	Mid	11	8		19 (34.5)
	Interior	12	6		18 (32.7)
	Total	35 (63.6)	20 (36.4)		55
Man-made	Edge	17	10	1	28 (45.9)
	Mid	13	8	1	22 (36.1)
	Interior	0	9	2	11 (18)
	Total	30 (49.2)	27 (44.3)	4 (6.5)	61

Table 4.14. Habitat types preference of avifauna in lower natural, upper natural and man-made glades habitats.

Glade types		**Habitat types preference**			
		Forest	**Forest edge**	**Woodland & forest edge**	**Total (%)**
Lower natural	Edge	25	7	1	33 (36.3)
	Mid	23	5	0	28 (30.8)
	Interior	23	4	3	30 (32.9)
	Total	71 (78)	16 (17.6)	4 (4.4)	91
Upper natural	Edge	14	2	2	18 (32.73)
	Mid	15	3	1	19 (34.54)
	Interior	16	1	1	18 (32.73)
	Total	45 (81.8)	6 (10.9)	4 (7.3)	55
Man-made	Edge	15	7	6	28 (45.9)
	Mid	13	4	5	22 (36)
	Interior	6	3	2	11 (18)
	Total	34 (55.7)	14 (23)	13 (21.3)	61

Table 4.15. The nesting habitats of avifauna in lower natural, upper natural and man-made glades habitats.

Glade types		**Nesting habitats**						
		Dwarf shrub	**Shrub multi stemmed (<5m)**	**Shrub single stem**	**Artificial objects**	**Tree**	**Shrub**	**Total (%)**
Lower natural	Edge	3	5	5	0	20		33 (36.2)
	Mid	1	3	6	1	17		28 ((30.8)
	Interior	2	4	6	1	17		30 (33)
	Total	6 (6.6)	12 (13.2)	17 (18.7)	2 (2.2)	54 (59.3)		91

Upper	Edge	2	4	3	8	1	18 (32.73)
natural	Mid	3	1	3	11	1	19 (34.54)
	Interior	2	3	3	10	0	18 (32.73)
	Total	7 (12.7)	8 (14.5)	9 (16.3)	29 (52.7)	2 (3.6)	55
Man-made	Edge	2	6	5	15		28 (45.9)
	Mid	2	4	4	4		11 (18)
	Interior	2	1	4	12		22 (36.1)
	Total	6 (9.8)	11 (18)	13 (21.3)	31 (50.8)		61

Table 4.16. The diet preference of avifauna in lower natural, upper natural and man-made glades habitats.

Glade types		**Diet preference**				
		Fruits	**Insects**	**Nectar**	**Seeds**	**Total (%)**
Lower natural	Edge	9	19	2	3	33 (36)
	Mid	6	17	2	3	28 (31)
	Interior	9	16	3	2	30 (33)
	Total	24 (26)	52 (57)	7 (8)	8 (9)	91
Upper natural	Edge	4	10	1	3	18.(32.73)
	Mid	7	10	0	2	19.(34.55)
	Interior	4	12	1	1	18.(32.73)
	Total	15 (27)	32 (58)	2 (4)	6 (11)	55
Man-made	Edge	8	16	2	2	28 (45.9)
	Mid	9	9	3	1	22.(36.1)
	Interior	4	4	2	1	11.(18.0)
	Total	21.(34.4)	29.(47.5)	7.(11.5)	4.(6.6)	61

Table 4.17. Environmental indicator birds at the forest edge (5-35 m) and interior (65 m) of the three study habitats.

Glade types	**Forest edge species name**	**Indicator value**	**Forest interior species name**	**Indicator value**
Upper natural	Montane White-eye	92.1***	Montane White-eye	56.6**
	MountainGreebul	75.8**		
	Brown Woodland Warbler	74.3*		
	African Dusky Flycatcher	53.3**		
Man-made	Common Bulbul	67.6**		
	Collard Sunbird	67.0*	Collard Sunbird	51.4*
	Black-throated Wattle-eye	57.9**		
	Chinspot Batis	57.6*		
Lower natural	None	None	None	None

*P<0.05; **P<0.01; ***P<0.001

Table 4.18. Environmental indicator birds observed across transects sampled at a distance 5 m, 35 m and 65 m distance from the edge.

Glade type	Species name	Distance (m)	Indicator value
Upper natural	Montane White-eye	5	97.2***
	Mountain Greenbul	5	80.0***
	African Dusky Flycatcher	5	53.3*
	Montane White-eye	35	73.8***
	Brown Woodland Warbler	35	56.6**
	Montane White-eye	65	51.4*
Man-made	Collard Sunbird	5	81.8***
	Black-backed Puffback	5	60.0*
	Common Bulbul	5	57.1*
	Grey-backed Camaroptera	35	50.8*
Lower natural	None	None	None

P<0.05; **P<0.01; ***P < 0.001

Table 4.19. Three way comparison between bird variables and edge distances between the three habitat types for forest birds.

Glade type	Bird variables	Distances (m)			ANOVA $F_{(2,12)}$
		5	35	65	
Man-made	Total abundance	5.24 ± 2.14	3.36 ± 1.30	1.16 ± 1.17	6.77***
Upper natural	Total abundance	3.56 ± 1.62	3.36 ± 1.52	3.56 ± 2.02	0.02
Lower natural	Total abundance	3.00 ± 2.98	3.20 ± 2.58	2.64 ± 1.51	0.07
Man-made	Species richness	9.40 ± 3.36	6.80 ± 1.64	2.20 ± 1.92	11.27***
Upper natural	Species richness	6.20 ± 3.19	6.60 ± 3.36	6.20 ± 1.92	0.03
Lower natural	Species richness	5.40 ± 3.36	5.60 ± 2.70	5.80 ± 1.64	0.03
Man-made	Species diversity	0.08 ± 0.10	0.02 ± 0.03	0.07 ± 0.09	0.84
Upper natural	Species diversity	0.08 ± 0.11	0.15 ± 0.15	0.18 ± 0.14	0.60
Lower natural	Species diversity	0.49 ± 0.28	0.75 ± 0.13	0.56 ± 0.22	1.91

***P < 0.001

Table 4.20. Three way comparison between bird variables and edge distances between the three habitats type for glade interior birds.

Glade type	Bird variables	Distances (m)			ANOVA $F_{(2,12)}$
		5	35	65	
Man-made	Total abundance	0.00 ± 0.00	1.20 ± 2.00	0.00 ± 0.00	1.00
Upper natural	Total abundance	1.20 ± 2.68	0.00 ± 0.00	0.00 ± 0.00	1.00
Lower natural	Total abundance	0.00 ± 0.00	2.40 ± 5.37	0.00 ± 0.00	1.00
Man-made	Species richness	0.00 ± 0.00	0.20 ± 0.45	0.00 ± 0.00	1.00
Upper natural	Species richness	0.20 ± 0.45	0.00 ± 0.00	0.00 ± 0.00	1.00
Lower natural	Species richness	0.00 ± 0.00	0.60 ± 1.34	0.00 ± 0.00	1.00
Man-made	Species diversity	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.00 -
Upper natural	Species diversity	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	-
Lower natural	Species diversity	0.00 ± 0.00	0.18 ± 0.41	0.00 ± 0.00	1.00

Table 4.21 Results of correlation and stepwise multiple regression analyses of bird diversity and vegetation indices.

Variables	Correlation	Contribution to coefficient of determination in regression analysis	Correlation	Contribution to coefficient of determination in regression analysis	Correlation
	Man-made	Man-made	Lower natural	Lower natural	Upper natural
Plant total abundance	0.04		0.00		
% Plant basal cover	0.31		-0.17		
% Plant canopy cover	0.16		0.03		
Plant species richness	-0.12		0.03		
Plant species diversity	-0.10		0.00		
Bird total abundance	-0.73***		-0.13		
Bird species richness	-0.80***		-0.17		
Bird species diversity	-0.04		0.26**		
% Tree canopy cover	0.30		-0.11		
Tree species richness	0.04*	0.05 (3)	0.08		
% Dwarf-shrub basal cover	-0.10		-0.20		
Dwarf-shrub species richness	-0.10		0.31**		
% shrub basal cover	-0.59**	0.10 (2)	-0.18		
Shrub species richness	-0.55**		-0.08		
% Grass basal cover	-0.13		-0.02		

Grass species richness	- 0.23		0.13	
% Forbs basal cover	0.17		-0.18	
Forbs species richness	-0.57**		0.15	
Edge birds	-0.84***		0.01	
Interior birds	-0.22		-0.37***	
Forest habitat users	-0.49**		0.01	
Forest edge habitat	-0.61***		-0.37***	0.14 (1)
Woodland & forest edge	-0.45**		0.00	
Nectar feeders	-0.26		-0.15	
Insects eaters	-0.88***	0.78 (1)	-0.06	
Fruit eaters	-0.57**		-0.26**	
Seed eaters	-0.46**		-0.15	
Mixing foraging substratum	-0.45**		-0.30**	
Ground and grass (low substratum)	-0.47**		-0.14	
Aerial foraging	-0.70***		-0.08	
Shrub single stem (nest site)	-0.47**		-0.20	
Dwarf shrub (nest site)	0.33		0.00	
Hole in tree (nest site)	-0.20		-0.19	
Shrub multi-stemmed (nest site)	-0.36		-0.13	
Artificial object (nest site)			0.13	

1 Edge distance as dependent variable

2 * = P < 0.05, ** = P < 0.01, *** = P < 0.001,

3 Contribution to multiple coefficient of determination and (order of entry into regression model)

Table 4. 22. Showing the proportion edge area for upper and lower natural glades against interior in relation to the total area of Mount Meru Game Reserve (MMGR).

Glade name	**size m^2**	**Glade interior (r)**	**Edge distance area (m)**	**Forest edge-r**	**Edge area of the ring ($m^{2)}$**	**Edge area of the ring Km^2**	**MMGR interior area Km^2**	**MMGR Total area Km^2**
G1	7679	49.5	43	92.5	19160.0	0.02		
G3A	6092	44.0	43	87.0	17700.3	0.02		
G3B	33309	103.0	43	146.0	33618.6	0.03		
G3C	5667	42.5	43	85.5	17277.9	0.02		
G7	6403	45.2	43	88.2	18000.1	0.02		
G9	8240	51.2	43	94.2	19639.2	0.02		
G10	3568	33.7	43	76.7	14908.7	0.01		
G11	9463	54.9	43	97.9	20630.3	0.02		
G12	17795	75.3	43	118.3	26134.7	0.03		
G13B	32835	102.3	43	145.3	33420.0	0.03		
G14A	26524	91.9	43	134.9	30624.8	0.03		
G14B	2282	27.0	43	70.0	13085.7	0.01		
G19A	7733	49.6	43	92.6	19206.9	0.02		
G19B	3453	33.2	43	76.2	14760.8	0.01		
G22	2975	30.8	43	73.8	14117.9	0.01		
G25	3239	32.1	43	75.1	14478.8	0.01		

G26	3345	32.6	43	75.6	14619.6	0.01		
G27	13108	64.6	43	107.6	23253.3	0.02		
G28	2068	25.7	43	68.7	12735.9	0.01		
G29	3037	31.1	43	74.1	14204.0	0.01		
				Total	**391577.5**	**0.36**	**65.64**	**66**

Table 4. 23. Glade names and shape index for Mount Meru Glades.

Glade Name	Length (m)	Width (m)	Shape index
Glade no1	410	190	0.46
Glade no 2 a	390	380	0.97
Glade no 2 b	170	120	0.71
Glade no 3 a	940	330	0.35
Glade no 3 b	250	180	0.72
Glade no 9	530	210	0.40
Glade no 10	420	150	0.36
Glade no 11	550	300	0.55
Glade no 12	490	27	0.06
Glade no 13 a	780	260	0.36
Glade no 13 b	510	360	0.71
Glade no 14 a	780	350	0.45
Glade no 14 b	240	200	0.83
Glade no 15	840	440	0.52
Glade no 19 a	340	100	0.29
Glade no 19 b	260	160	0.62
Glade no 22	190	190	1.00
Glade no 25	270	160	0.59
Glade no 26	600	140	0.23
Glade no 27	810	440	0.54
Glade no 28	340	170	0.50
Glade no 29	380	180	0.47

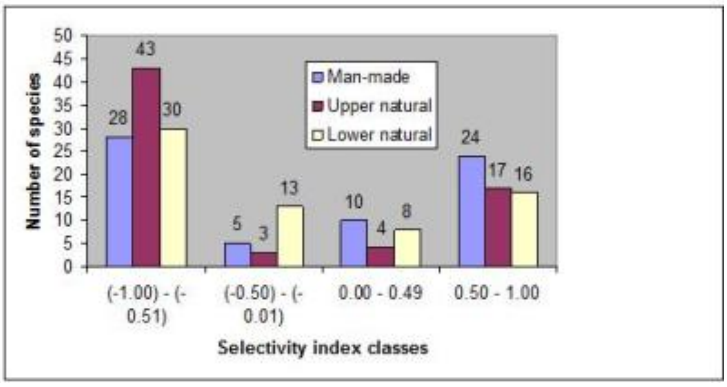

Fig. 4.2. Number of bird species in each habitat-selectivity class, based on Ivlev's index, for three study habitats. Habitat selection classes: 0.50 to 1.00 = strong selection for a habitat, -0.51 to -1.00 = strong avoidance for a particular habitat.

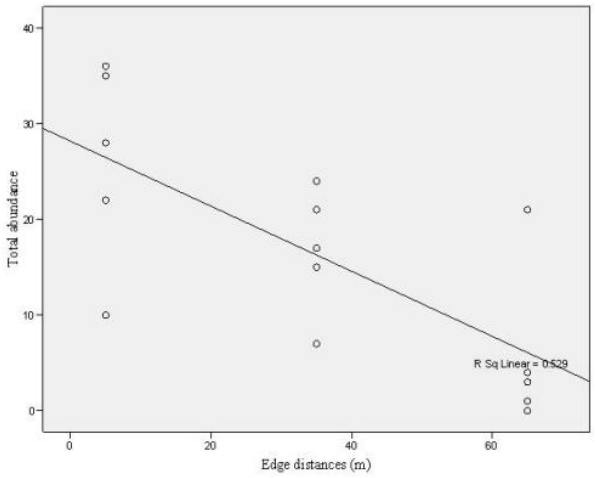

Fig. 4.3. Relationship between total abundance and edge distances for man-made glades.

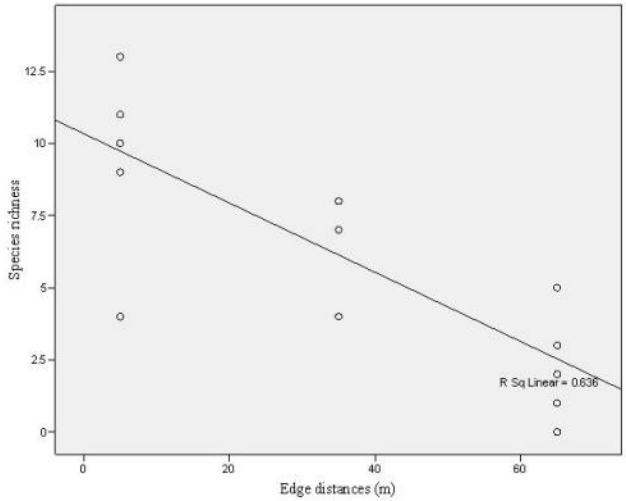

Fig. 4.4 Relationship between species richness and edge distances for man-made glades.

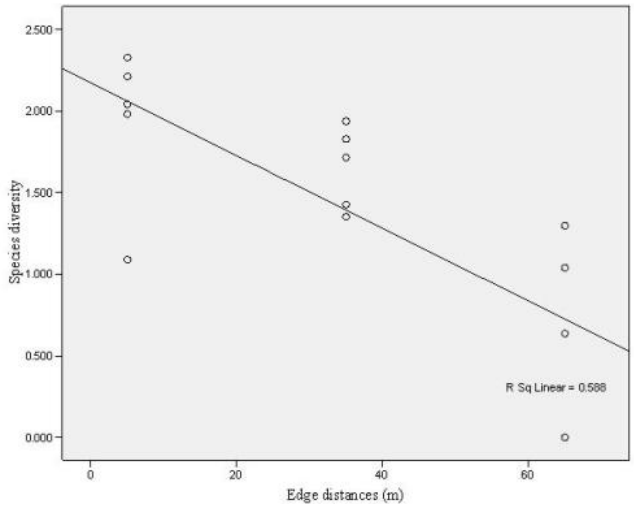

Fig. 4.5. Relationship between bird species diversity and edge distance for man-made glades

Appendix 4.1. The avifauna (n=68 species) recorded in the forest of the three habitat types man-made lower and upper natural glades and n=5 species in the Glades.

S/N0	Species	Scientific name
1	Collared Sunbird	*Hedydipna collaris*
2	Olive Sunbird	*Cyanomitra olivacea*
3	Forest Batis	*Batis mixta*
4	Hartlaub's Turaco	*Tauraco hartlaubi*
5	White-starred Robin	*Pogonocichla stellata*
6	Moustached Green Tinkerbird	*Pogoniulus leucomystax*
7	Montane White-eye	*Zosterops poliogaster*
8	African Dusky Flycatcher	*Muscicapa adusta*
9	Brown Woodland Warbler	*Phylloscopus umbrovirens*
10	Grey- headed Negrofinch	*Nigrita canicapilla*
11	Grey-backed Camaroptera	*Camaroptera brachyuran*
12	African Black-headed Oriole	*Oriolus larvatus*
13	Black-capped Apalis	*Apalis nigriceps*
14	Black Saw-wing	*Psalidoprocne holomelas*
15	Black-headed Apalis	*Apalis melanocephala*
16	Black-throated Wattle-eye	*Platysteira peltata*
17	Striped-cheeked Greenbul	*Andropadus milanjensis*
18	Speckled Mousebird	*Colius striatus*
19	Chin-spot Batis	*Batis molitor*
20	African Hill-babbler	*Pseudoalcippe abyssinica*
21	Green-backed Twinsspot	*Mandingoa nitidula*
22	Black Cuckoo-shrike	*Campephaga flava*
23	Black-fronted Bush-shrike	*Malaconotus nigrifrons*
24	Black-backed Puffback	*Dryoscopus cubla*
25	Black-and-white Mannikin	*Lonchura bicolor*
26	Lemon Dove	*Aplopelia larvata*
27	Little Greenbul	*Andropadus virens*
28	Kenrick's Starling	*Poeoptera kenricki*
29	Tropical Boubou	*Laniarius aethiopicus*
30	Ruppel's Robin-chat	*Cossypha semirufa*
31	Common Bulbul	*Pycnonotus barbatus*
32	Common Stonechat	*Saxicola torquata*
33	Common Waxbill	*Estrilda astrild*
34	Cabani's Greenbul	*Phyllastrephus cabanisi*
35	Taveta Golden Weaver	*Ploceus castaneiceps*
36	Trilling Cisticola	*Cisticola woosnami*
37	Thick-billed Seedeater	*Serinus burtoni*
38	Bar-tailed Trogon	*Apalodrma vittatum*
39	Bar-throated Apalis	*Apalis thoracica*
40	Brown-crown Tchagra	*Tchagra australis*
41	Brown-breasted Barbet	*Lybius melanopterus*
42	White-eared Barbet	*Stactolaema leucotis*
43	White-eyed slaty Flycatcher	*Melaenornis fischeri*
44	Common Buzzard	*Buteo buteo*
45	Yellow-breasted Apalis	*Apalis flavida*
46	African Paradise- flycatcher	*Terpsiphone viridis*
47	Lesser Honeyguide	*Indicator minor*

48	Evergreen Forest Warbler	*Bradypterus lopezi*
49	Mountain Greenbul	*Andropadus nigriceps*
50	Scaly Francolin	*Francolinus squamatus*
51	Olive Woodpecker	*Dendropicos griseocephalus*
52	Variable Sunbird	*Cinnyris venusta*
53	Abbysinica Crimsonwing	*Cryptospiza salvadorii*
54	Yellowbill Coucal	*Ceuthmochares aereus*
55	Blue mantled crested Flycatcher	*Trochocercus cynomelas*
56	Cape Robin-chat	*Cossypha caffra*
57	Scaly-throated Honeyguide	*Indicator variegates*
58	Montane thrush	*Turdus abyssinicus*
59	Mountain Yellow Warbler	*Chloropeta similes*
60	Crowned Hornbill	*Tockus fasciatus*
61	African Emerald Cuckoo	*Chrysococcyx cupreus*
62	African Green-pigeon	*Treron calva*
63	Red-headed Weaver	*Anaplectes rubriceps*
64	Silvery cheeked Hornbill	*Bycanistes brevis*
65	Amethyst Sunbird	*Chalcomitra amethystine*
66	Africanwood Owl	*Strix woodfordii*
67	Crowned Hornbill	*Tockus alboterminatus*
68	Red-chested Cuckoo	*Cuculus solitarius*
	Glade interior	
1	African Citril	*Serinus citrinelloides*
2	Green Sandpiper	*Tringa ochropus*
3	Egyptian Goose	*Alopochen aegyptiacus*
4	Black Stork	*Ciconia nigra*
5	Black-and-white Mannikin	*Lonchura bicolour*

Appendix: 4. 2. Ecological traits of birds recorded in the three habitat types man-made, lower and upper natural glades.

Species	Natural habitat	Diet Class	Foraging substratum	Nest	Endemism	Distribution	Status
Collard Sunbird	F	N	MF	SSS	Ne	R	Nt
Olive Sunbird	F	N	AF	SSS	Ne	R	Nt
Forest Batis	F	I	AF	T	Ne	R	Nt
Hartlaub's Turaco	F	F	AF	T	Ne	R	Nt
White-starred Robin	F	I	GG	G	Ne	R	Nt
Moustached Green Tinkerbird	F	F	AF	T	Ne	R	Nt
Montane White-eye	F	F	AF	T	Ne	R	Nt
African Dusky Flycatcher	FE	I	AF	T	Ne	R	Nt
Brown Woodland Wabler	F	I	AF	SSS	Ne	R	Nt
Grey-headed Negrofinch	F	S	MF	T	Ne	R	Nt
Grey-backed Camaroptera	FE	I	GG	SSS	Ne	R	Nt
African Black- headed Oriole	F	I	AF	H	Ne	R	Nt
Black-capped Apalis	F	I	AF	SMS	Ne	R	Nt
Black Saw- wing	O	I	AF	RB	Ne	R	Nt
Black-headed Apalis	F	I	AF	T	Ne	R	Nt
Black-throated Wattle-eye	F	I	AF	T	Ne	R	Nt
Striped-cheeked Greenbul	F	F	AF	T	Ne	R	Nt
Speckled Mousebird	S/FE	F/S	AF	SMS	Ne	R	Nt
Chin-spot Batis	FE	I	AF	T	Ne	R	Nt
African Hill-babbler	F	I	GG	SMS	Ne	R	Nt
Green-backed Twinsspot	FE	S	GG	SMS	Ne	R	Nt
Black Cuckoo-shrike	F	I	AF	T	Ne	R	Nt
Black fronted bush shrike	F	I	AF	T	Ne	R	Nt
Black backed Puffback	FE	I	AF	T	Ne	R	Nt
Black-and- white Mannikin	FE	S	GG	SMS	Ne	R	Nt
Lemon Dove	F	S	GG	T	Ne	R	Nt
Little Greenbul	F	F	GG	T	Ne	R	Nt
Kenrick’s Starling	F	F/I	AF	H	Ne	R	Nt
Tropical Boubou	FE	I	GG	SMS	Ne	R	Nt
Ruppel's Robin-chat	FE	I	GG	SMS	Ne	R	Nt
Common Bulbul	FE/W	F	GG	T	Ne	R	Nt
Common Stonechat	W/F/E	F/I	GG	DS	Ne	R	Nt
Common Waxbill	W/F/E	S	GG	DS	Ne	R	Nt

Brown Woodland Warbler	F	I	GG	T	Ne	R	Nt
Cabani's Greenbul	F	I	GG	T	Ne	R	Nt
Taveta Golden Weaver	W	S	AF	SSS	Ne	R	T
Trilling Cisticola	W/S	I	GG	DS	Ne	R	Nt
Thick-billed Seedeater	F/E	S	AF	S	Ne	R	Nt
Bar-tailed Trogon	F/S/W	I	AF	H	Ne	R	Nt
Bar-throated Apalis	F/S/W	I	AF	SMS	Ne	R	Nt
Brown-crown Tchagra	F/E/W	I	GG	SMS	Ne	R	Nt
Brown-breasted Barbet	F/E	F	AF	H	Ne	R	Nt
White-eared Barbet	F/W	F	AF	H	Ne	R	Nt
White-eyed slaty Flycatcher	F/E	F	AF	T	Ne	R	Nt
Common Buzzard	F/W	SV	GG	T	Ne	R	Nt
Yellow-breasted Apalis	F/E/W	I	AF	SMS	Ne	R	Nt
African Paradise-flycatcher	F/W	I	AF	SSS	Ne	R	Nt
Lesser Honeyguide	F/E	I	AF	H	Ne	R	Nt
Evergreen Forest Warbler	F	I	GG	DS	Ne	R	Nt
Mountain Greenbul	F	F	AF	T	Ne	R	Nt
Scaly Francolin	F	I	GG	G	Ne	R	Nt
Olive Woodpecker	F	I	AF	H	Ne	R	Nt
Variable Sunbird	W	N	AF	SSS	Ne	R	Nt
Abbysinia Crimsonwing	F	S	GG	SSS	Ne	R	Nt
Yellowbill Coucal	F/E	I	AF	SMS	Ne	R	Nt
Blue mantled creasted Flycatcher	F	I	AF	SSS	Ne	R	Nt
Cape Robin-chat	W	I	GG	SMS	Ne	R	Nt
Scaly-throated Honeyguide	F	I	AF	H	Ne	R	Nt
Montane thrush	F	I	GG	SSS	Ne	R	Nt
Mountain Yellow Warbler	F	F	AF	DS	Ne	R	Nt
Crowned Hornbill	F	I/SV	AF	H	Ne	R	Nt
African Emerald Cuckoo	F	I	AF	AO	Ne	R	Nt
African Green-pigeon	F/W	F	AF	T	Ne	R	Nt
Red-chested Cuckoo	F/E	I	AF	AO	Ne	R	Nt
Red-headed Weaver	F	I	AF	SSS	Ne	R	Nt
Silvery cheeked Hornbill	F	F/SV	AF	H	Ne	R	Nt
Amethyst Sunbird	F/E/W	N	AF	SSS	Ne	R	Nt
Africanwood Owl	F	I	AF	H	Ne	R	Nt
Crowned Hornbill	F	F	AF	H	Ne	R	Nt
African Citril	W/F/E	S	AF	SSS	Ne	R	Nt

Green Sandpiper	M	I	W	RB	Ne	R	Nt
Egyptian Goose	M	I/G	W	T	Ne	R	Nt
Black Stork	M	I/G	W	T	Ne	R	Nt

Preferred habitat: F= Forest, FE= forest edge, W= woodland

Diet Class: I = Invertebrates, SV= small vertebrates, S=Seed, F= Fruits, N=Nectar

Foraging substratum: AF= Aerial foraging; tree or shrub(medium to high substratum;
GG= Ground and grass (low substratum)
MF= Mixed foraging substratum(Air, tree, ground)

Nest site: On ground, grass, forbs, dwarf shrubs(ds) (<1m above ground)
Shrubs single stem(SSS)< 2 M
Shrubs multi-stemmed (SMS)< 5 M and trees
Hole in tree (H)
Artificial object (AO)
Near of above water in marshes, reeds, riverbank

Endemism: Southern Africa endemic; Afrotropic endemic(excluding southern Africa; Non endemic

Regional status: Resident(R); Migrant(M)

Conservation status: Non-threatened; threatened