TRIALING FOREST MANAGEMENT SOLUTIONS FOR LONG-BILLED TAILORBIRD IN AMANI NATURE RESERVE, TANZANIA

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Summary

Forest edge habitats in the tropics host high levels of biodiversity, including globally threatened species. In the endemic-rich area known as East Usambara Mts, Tanzania, damaging human activities at the forest edge reduces biodiversity, and is thought to threaten the Critically Endangered Long-billed Tailorbird *Artisornis moreaui*. This study was done from 2012 to February 2014 to evaluate the restoration of forest edge habitat towards the increase of bird diversity. This was done by working in partnership with local farmers and censusing the plots in three treatments for forest birds and vegetation. The three treatments were Bush regrowth (permit no disturbance and allow forest habitat to re-grow naturally), Control (natural forest edge habitat), and *Shamba* (permit farming activities as normal). The results showed that Bush-re-growth increased bird diversity and abundance over time, and that reducing adverse human activities at the edge benefits biodiversity.

Introduction

The forests of the Eastern Arc Mountains in Kenya and Tanzania are amongst the most diverse biodiversity hotspots in the world and house an astonishing level of endemism. Despite their conservation importance, these forests have suffered from extensive habitat loss, degradation and fragmentation, largely as a result of land-use changes driven by human activities. These changes pose a significant threat to the long-term survival of species dependent on these forests, such as the Long-billed tailorbird (*Artisornis moreaui*), listed by the IUCN red list as Critically Endangered. This species is currently recognized as having two widely separated sub populations, around 1000km apart, but BirdLife International now recognises each population as a separate species. In Tanzania, which apparently holds the majority of the population (ca.80%), this species is only known to exist in the East Usambara Mountains (hereafter EUM) of the Eastern Arc, where this study focused. The other sub population, recently rediscovered in 2003 (Ryan and Spottiswoode 2003), occurs in the Njesi Plateau of Northern Mozambique (Benson, 1946), of which very little is known.

Conservation problem

The population of Long-billed Tailorbird (hereafter LBT) in the wild is less than 250 individuals, according to the most recent study (Baker and Baker, 2002). Our recent unpublished evidence suggests declines at some sites, but these data are awaiting analysis. In EUM, the species' primary habitats are forest edges and early successional habitats within the forest interior, particularly canopy gaps with a high vine/climber density (McEntee *et al.* 2005). This suggests that LBT might be dependent on recurrent, low-intensity, disturbance (Borghesio 2010). However, it is also clear that areas with constant and intense human disturbance are not favoured. LBT is highly vulnerable to forest destruction and fragmentation (Borghesio, 2010). Although the extent of protected forest in the EUM has increased, there is heavy pressure on patches of unprotected forest, and along forest edges, especially for mining, pole-cutting, cultivation and firewood-collection. As this forest becomes depleted, pressure on smaller forest patches is likely to increase. In addition, harvesting of plants for medicinal purposes may cause some disturbance and clearance of vegetation along powerlines has resulted in the loss of some territories. Finally, invasive species, such as the tree *Maesopsis eminii*, appear to reduce habitat suitability (Borghesio 2010). Preliminary evidence from the monitoring that we have been carrying out since 2006, suggests that, in the EUM, disturbance and degradation are particularly intense along forest edges. As a consequence, LBT has frequently been observed along undisturbed forest edges, but the species is rare where edges are severely disturbed by human activities (John *et al.* 2009). The species is now more frequently recorded in the interior of the Amani Nature Reserve (ANR) compared to the forest edge (Borghesio, 2010). We hypothesize that increased human disturbance along forest edges is one of the primary causes of LBT decline.

Species and associated habitat conservation status and threats

The Long-billed Tailorbird is a small insectivorous passerine bird with an extremely small range, encompassing only two sites, separated by a gap of more than 1000 km: the Njesi Plateau in northern Mozambique (Benson 1946; Ryan & Spottiswoode 2003) and the East Usambara Mountains (05°04"N 38°36"E) in northern Tanzania (Baker & Baker 2001). In total, the world range of this species might be less than 1000 km2, and the total population is currently estimated to only 50-249 individuals (BirdLife International 2010), of which 150-200 (80%) are found in the EUM (Cordeiro et al. 2001). Knowledge of the population trend is poor, but is thought to be negative due to continuing habitat degradation over the entire range (BirdLife International, 2010). LBT thus qualifies for the highest threat category in the IUCN criteria –

Critically Endangered, meaning it is at an extremely high risk of extinction in the wild, quantified at 50% chance of extinction within the next 10 years (IUCN 2010). LBT inhabits large canopy gaps and edges with dense shrub and vines, in submontane and montane forest (Cordeiro et al. 2001, McEntee *et al.* 2005). The species is severely affected by forest fragmentation and habitat degradation, and while it may disperse to small fragments close to the continuous forest, it does not persist in such habitat. Major threats to LBT include an exotic and invasive tree, *Maesopsis eminii*, which takes over natural habitats and impedes the development of vines and climbers. LBT is also threatened by habitat degradation along forest edges. This is due to increased human pressure and agricultural expansion, especially when these activities cause the removal of shrubs and lianas. Improvement of habitat quality along forest edges could therefore generate substantial increments of the LBT population in the EUM.

Due to human disturbance being a major problem for biodiversity such as LBT along forest edges, three primary objectives were evaluated as part of this study:

1. Increase understanding of the forest edge habitat requirements of this species
2. Improve the quality of forest edge habitat for the species
3.Build capacity for nature conservation in Tanzania

MATERIALS AND METHODS

Study Site

The study was conducted in the EUM within the area of 8,380 ha, at the altitudinal range between 800-1100 m.a.s.l, where *LBT* is known to occur (Cordeiro *et al.,* 2001, Borghesio, 2011). The EUM are found between the latitudes 4º 48'S-5º 13'S and 38º 32 E -38º 4º E (Johansson *et al.,* 1998). The sites were located in villages of Mlesa, Kwamkoro, Sangalawe and Emau (Figure 1). The suitability of the EUM for this study was attributed by the following reasons: First, the avifaunal resources in this area have been well studied providing enough baseline information for reference. Second, the EUM are rich in rare and endemic species and those which are restricted in their geographical range including the enigmatic *LBT*. Third, the EUM is the only area where this species can be found in Tanzania. Fourth, the EUM have the required habitat preferred by *LBT* and other species of birds. Apart from the suitability, the habitat is located within

optimum altitudinal limits for *LBT*. Fifth, the EUM has a long history of deforestation and forest fragmentation. This have availed enough vegetation characteristic of forest edge to save for study purposes. The sixth reason was readiness of farm owners to offer plots for study purposes.

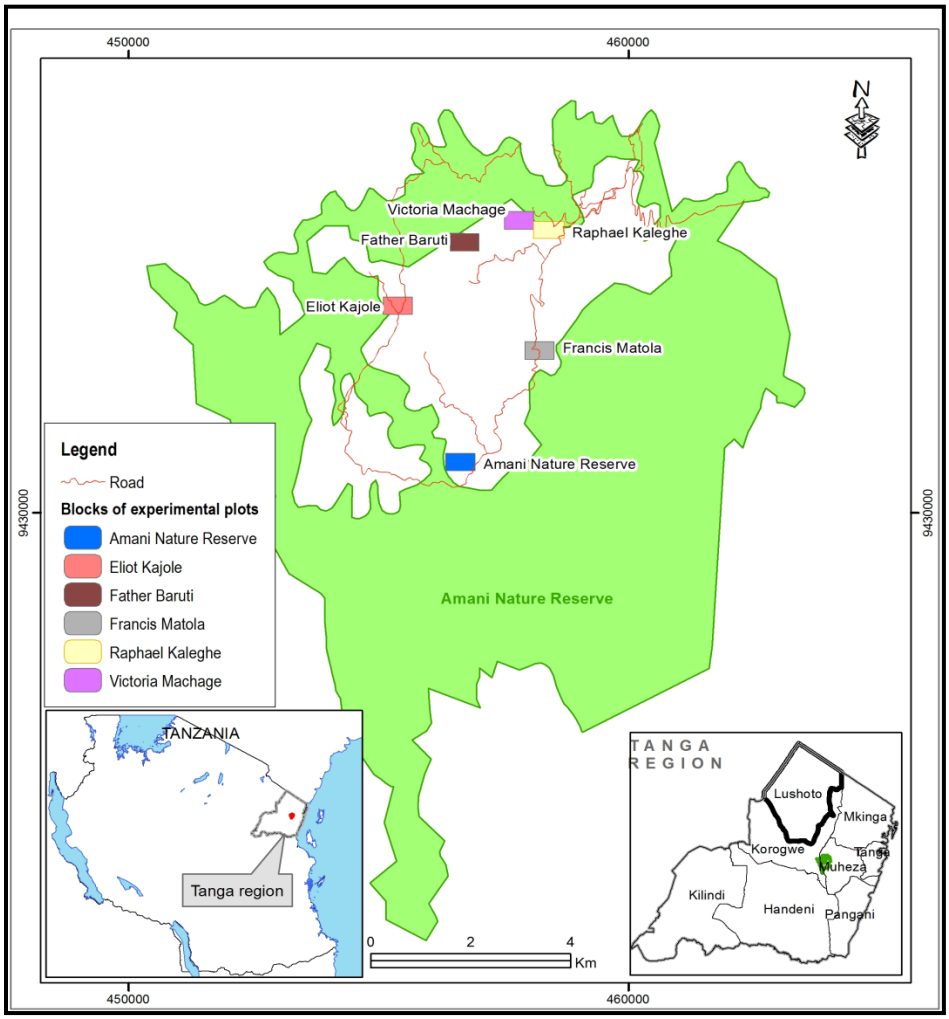

Figure 1 : A map showing location of blocks of sampling plots (Nsajigwa, 2016)

Methods

Six private smallholder farms were selected in August 2012. These were categorized into Control, Bush re-growth and *Shamba* plots. The selection was followed by signing the contractual agreements with the land

owners. The criteria for selection of plots were: location of farm along the edge of the forest, in a place where LBT was not existing, but known to occur within a radius of < 500 m. Fifteen of these farms were divided into triplets each consisting of plots of 30 m x 60 m in size (Miller *et al.,* 2009). In this case, a triplet comprising of Bush re-growth, *Shamba* and Control plots formed one block. Owing to difficulties encountered in acquiring farms of required sizes, the three plots in Kwamkoro were 50 m x 25 m in size (Whaley, 1997). The long side of each plot was set to run parallel to forest edge. For easy location during data collection, each corner was installed with a wooden peg, each with a yellow flag. The coordinates for each of the four corners of every plot were recorded at the beginning of data collection using a GPS. The coordinates are as shown in appendix 3. Plots had similar elevation, aspect, vegetation and abundance of the invasive tree *M. eminii*. The *M. eminii* trees and saplings which were present in plots at the beginning of the study were not removed.

The arrangement of plots was as follows: The first was to serve as Control plot. This was a plot located along forest edge adjacent to the Bush re-growth plot. In this plot, human activities such as pole cutting, cultivation, animal grazing, and collection of fire-wood were allowed. The second was a Bush re-growth plot, located along forest edge, similar to Control plot. In this plot, human activities were completely stopped. In order cessation of human activities in these plots, binding contractual agreements were entered between the student and land owners through which compensation was paid to each owner. The third was the *Shamba* plot. *Shamba* is a *Kiswahili* word that stands for a farm or plot used for cultivation of crops. This was located approximately thirty two meters from the edge of the forest (Figure 2). In this plot, human activities were allowed.

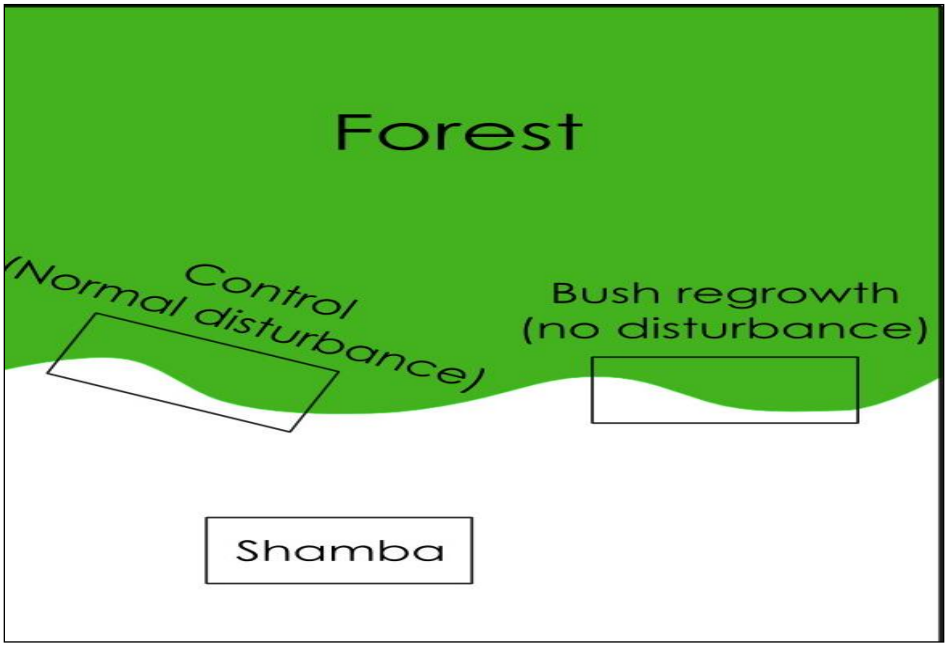

Figure 2: The layout of Bush re-growth, Control and *Shamba* plots

Within the area of each plot, two parallel lines with a distance of 10 m apart were established between two ends, and ran along the length of the plot. In each line, there were six sampling points each within a span of 10 m. Therefore, there were twelve sampling points in each plot. A sampling point was a circle with a radius of 2.5 m (United States Environmental Protection Agency, 2012) (Figure 3). Sampling of both birds and vegetation started six months after the date of signing the contractual agreements with owners of plots.

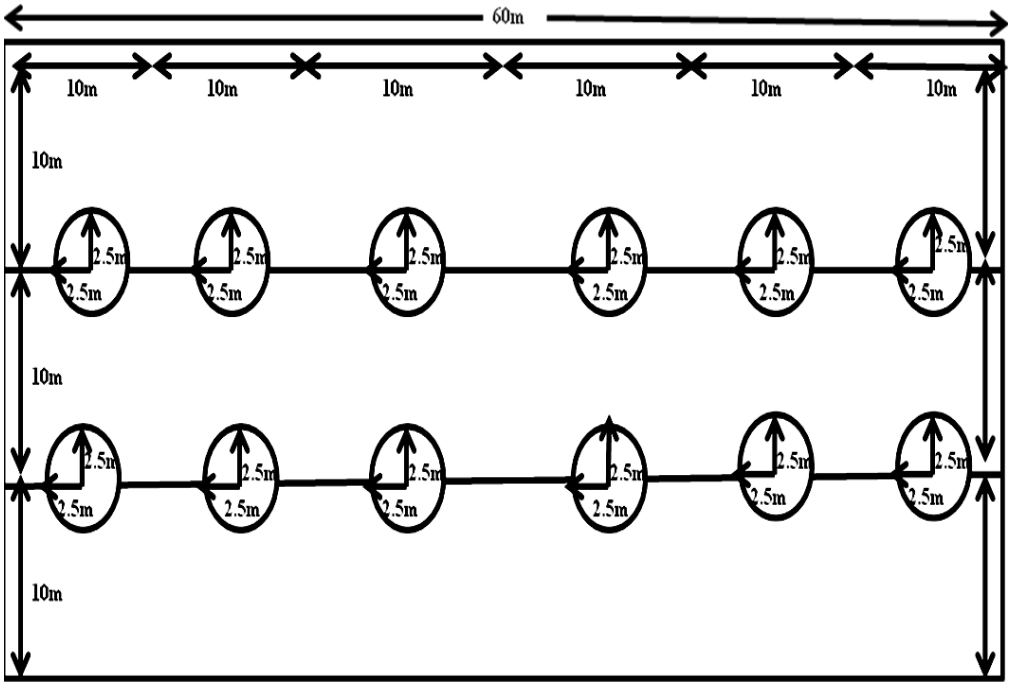

Figure 3: An illustration of layout and distribution of sampling points in a plot.

2.2.2. Sampling of Vegetation

Sampling of vegetation was carried out eight times, particularly in August and October 2012, February, June, August, October, December 2013 and February 2014. The main objective was to determine the re-growth of vegetation (< 5 m tall). There were twelve sampling points in each plot. At each sampling point, two plant species with the highest percentage cover in the bush layer within a circle of radius of 2.5 m from the centre were recorded. Therefore, 24 records were obtained from each of the sampling points. Finally, sampling of height of vegetation at the centre and all four cardinal directions of each circle was carried out. For rapid estimation of these distances, a marked bamboo pole was used. Preliminary identification of plant specimen was done in the field. The specimen were processed and transferred to University of Dar-Es-Salaam (UDSM) for further identification. The voucher specimens are stored at the University herbarium for reference.

2.2.3 Measurement of Chequered Board Half Disappearance Distances (CBDD)

The chequered board (4 x 4) was used to measure the Half Disappearances Distance in plots (Bibby *et al.,* 2000). The chequered board consisted of four levels each with two black and two white squares (Figure XXX). The CBDD were measured on the two parallel lines running along the 60 m length of each plot, within the intervals of ten meters. Thus, there were six sections of ten meters along the length. The observer would position himself at a fixed point at the beginning of the ten meter band within the line. One person would hold the board at the breast height to display it in front of the observer. The observer would count the number of squares obscured by thick vegetation. The board holder would be instructed by an observer to move towards or away from the observer along the line, to a distance where only half of the squares were visible and half were invisible to the observer owing to obstruction by thickness of vegetation. This distance was referred to as the Chequered Board Half Disappearance Distance. After completion of one point, the board holder and the observer would move to the next band of ten meters and repeat the same procedures. A minimum of 12 half-disappearance measures were recorded in each plot.

Plate 1: A field assistant portraying a chequered board during assessment of Half Disappearance Distance (June, 2013).

Sampling of Birds

Parallel to sampling of vegetation, birds were also sampled in August, October 2012, February June, August, October, December 2013 and February 2014. For simplicity, samplings of birds and vegetation were done the same day. Each plot was visited between 6:30-9:30 am for conducting the bird census. The entire plot was walked slowly by one observer for 15 minutes. Detection of birds relied on both visual and aural cues. All birds (species and numbers) which were seen or heard inside the plot during this time were recorded in a list. Being a skulking and often silent species, playback of vocalizations of *LBT* was conducted three times for 1 minute at time 0, 5 and 10 minutes of the 15 minute count. Birds within the plots were recorded. For birds observed outside of the plots, the data was marked as outside with a symbol "O".

RESULTS

Bird Species Abundance in Bush re-growth, Control and *Shamba* Plots

Bird Species Cumulative Curves for Bush re-growth, Control and Shamba Plots

The Bush re-growth plots were the richest in bird species (75) than *Shamba* (58) and the Control plots (56). During sampling, the numbers of new species were gradually increasing with increase in sampling efforts in all plot categories. The three species curves did not reach the points of asymptote. This indicated that the majority of bird species were recorded at the end of the sampling period, though more species would possibly be recorded with further sampling efforts (Figure 4).

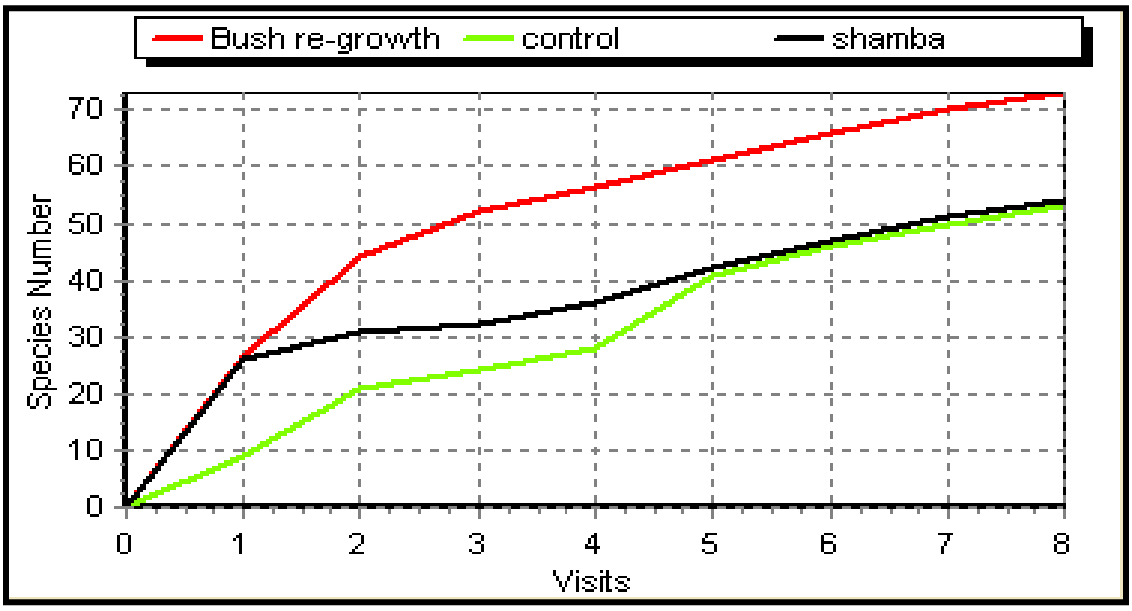

Figure 4: The cumulative curves showing numbers of bird species recorded from August 2012 to February 2014.

Comparison of Bird Species Abundances among Bush re-growth, *Shamba* and Control Plots

A total of 1067 birds were recorded. There was a significant difference in bird species abundance among three plot categories (Kruskal-Wallis H = 12.2, df = 3, P = 0.0012; Figure 5). In comparison, the Bush re-growth plots had highest abundance of birds than Control and *Shamba* plots (Figure 8). In overall, the Little Greenbul, Common Bulbul and the Olive Sunbird were the most abundant species in Bush re-growth, Control and the *Shamba* plots, respectively.

The list of the most abundant bird species is shown in Table 1.

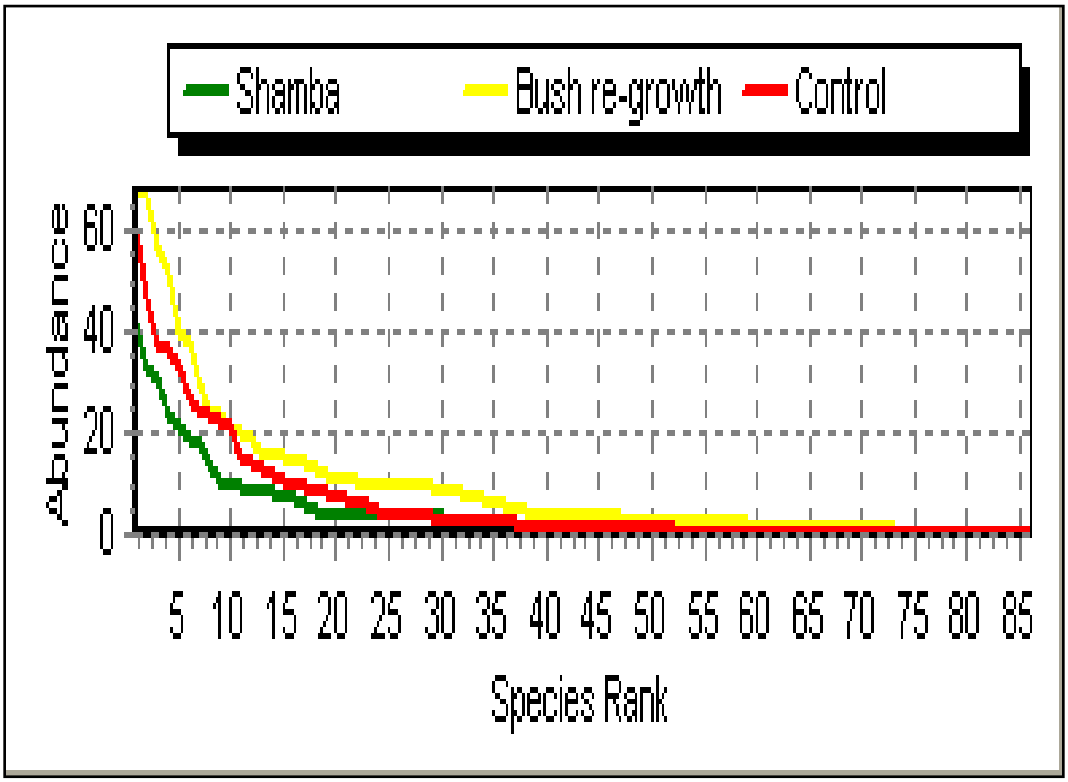

Figure 5: The relative abundance of birds versus bird Species Ranks where

Table 1: The most abundant bird species (mean number of individuals per plot) in Bush re-growth, Control and the *Shamba* plot categories

Bird Species	**Bush re-growth**	**Control**	***Shamba***
Olive Sunbird *Cyanomitra olivacea*	8.7	6.4	9.5

Little Greenbul *Andropadus virens*	8.5	-	-
Speckled Mousebird *Colius striatus*	6.5	7.0	9.5
Collared Sunbird *Hedydipna collaris*	5.1	-	-
Yellow White-eye *Zosterops senegalensis*	4.7	-	-
Common Bulbul *Pycnonotus barbatus*	9.2	11.7	11.8
Black-and-White Mannikin *Lonchura bicolor*		9.2	6

Bird Species Diversity

In overall, the bird species diversity index (H') of the area was 3.8. However, the Bush re-growth plots were the most diverse in bird species (H' =3.7), followed by the Control plots (H' = 3.5) and the *Shamba* plots (H' = 3.4). Comparatively, there was a significant difference in species diversity between Bush re-growth and the Control plots ($t = -4.9$, $df = 486$, $P < 0.001$), and between Bush re-growth and *Shamba* plots ($t = -7$, $df = 486$, $P < 0.001$). However, the Control and *Shamba* plots showed no significant difference in diversity of bird species ($t = 1.53$, $df = 486$, $P = 0.13$). This was an indication that the Bush re-growth plots were the most preferred habitat for birds as a result of experimental treatment.

Occurrence of Long-billed Tailorbird

The LBT was neither seen nor heard calling or responding to the playback from all plots in the Bush re-growth, *Shamba* and Control plots. This is an indication that the species did not colonise the plots. However, very soon after the sampling ended for this thesis project, continued sampling showed that LBT occupied 50% of the plots by the end of 2014 into 2015.

Relationship between Height of Vegetation and Bird Species Diversity

Temporal Changes in Height of Vegetation

In general, the heights of plants in the Bush re-growth were comparatively higher than in the *Shamba* and Control plots in all sampling periods. However, temporal trend showed a sharp increase in height of vegetation in the Bush re-growth plots from August 2012 to October, 2012. The vegetation did not show fluctuations in heights in the subsequent sampling periods. The heights of vegetation were higher in Control

than in *Shamba* plots in August 2012. However, there were similar pattern of temporal fluctuations in the two plot categories from October to 2012 to February 2014 (Figure 6).

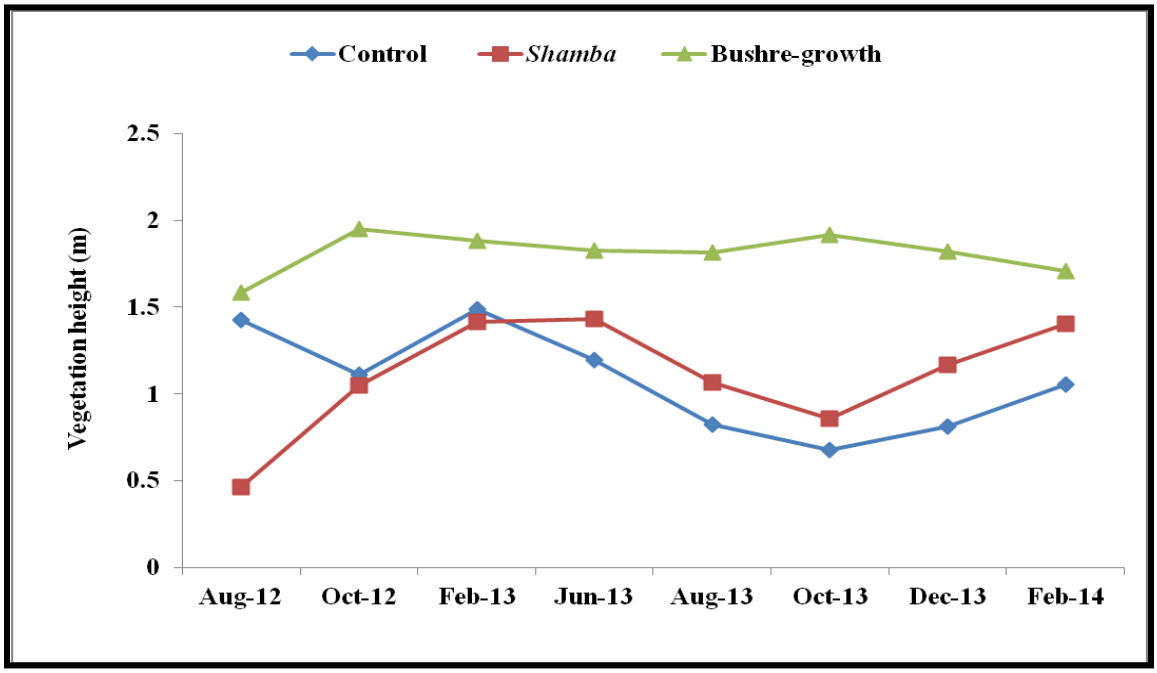

Figure 6: A graph showing temporal changes in vegetation heights in Bush re-growth, *Shamba* and Control plots between August 2012 and February 2014.

Temporal Changes in Half Disappearance Distances in Bush re-growth, *Shamba* and Control plots

Generally, the Bush re-growth plots had the lowest checkered board half disappearance distances than the Control and *Shamba* plots. On average, changes in seasons of the years had little influence on half disappearances in Bush re-growth plots. Approximately, equal disappearance distance was maintained from October 2012 to February 2014 in the Bush re-growth plots. On the other hand, the disappearance distances were highest in August 2012 and lowest in June, 2013, in Control and *Shamba* plots. The disappearance distances were influenced by changes in the seasons of the year. This is consistent with the observation that, the two plot categories maintained similar pattern of changes in height of vegetation during the entire period of sampling (Figure 7).

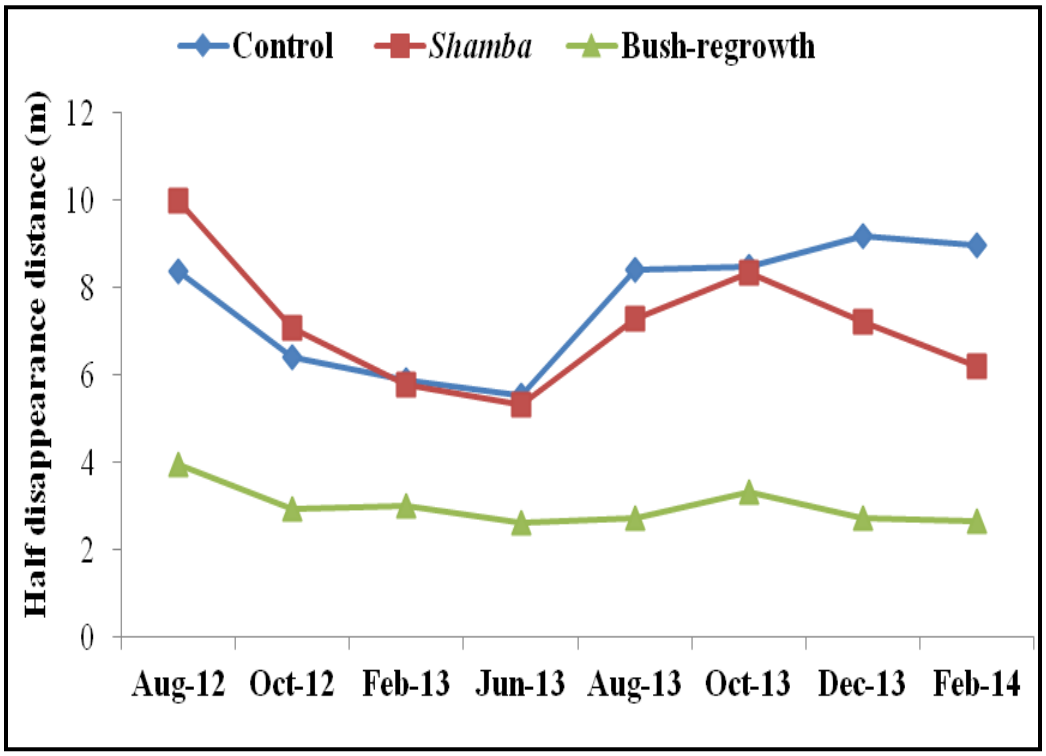

Figure 7: A graph showing temporal changes in checkered board half disappearance distances.

Correlation between Vegetation Height and Bird Species Diversity in Bush re-growth Control and *Shamba* Plots

There was weak negative correlation between heights of vegetation and bird species diversity in Bush re-growth plots (r_s = -0.2, n = 8, p = 0.16), and Control plots (rs = -0.11, n = 8, p = 0.42). A weak positive correlation was observed between height of vegetation and bird species diversity in *Shamba* plots (rs = 0.13, n = 8, p = 0.37). This indicates that apart from height of vegetation, diversity of birds possibly depends on a combination of factors such as diversity of plants and/ or foliage height diversity.

Temporal Changes in Number of Bird Species after experimental Treatment

The Bush re-growth plots had the highest number of bird species in all sampling periods as compared to *Shamba* and Control plots. The number of bird species however, fluctuated with season of the year in each plot category. In general, high numbers of bird species were observed in October 2012, and between October and December 2013, and low numbers were observed between February and June 2013. While

the number of species rose in August 2012 and 2013, there was a general decline in number of species in February 2013 and 2014 in all plot categories. The Control plots did not show a clear pattern of fluctuations in number of bird species from August 2012 to June 2013. Similar to Bush re-growth and *Shamba* plots, a clear pattern of fluctuations in this category of plots was observed between June 2013 and February 2014 (Figure 8).

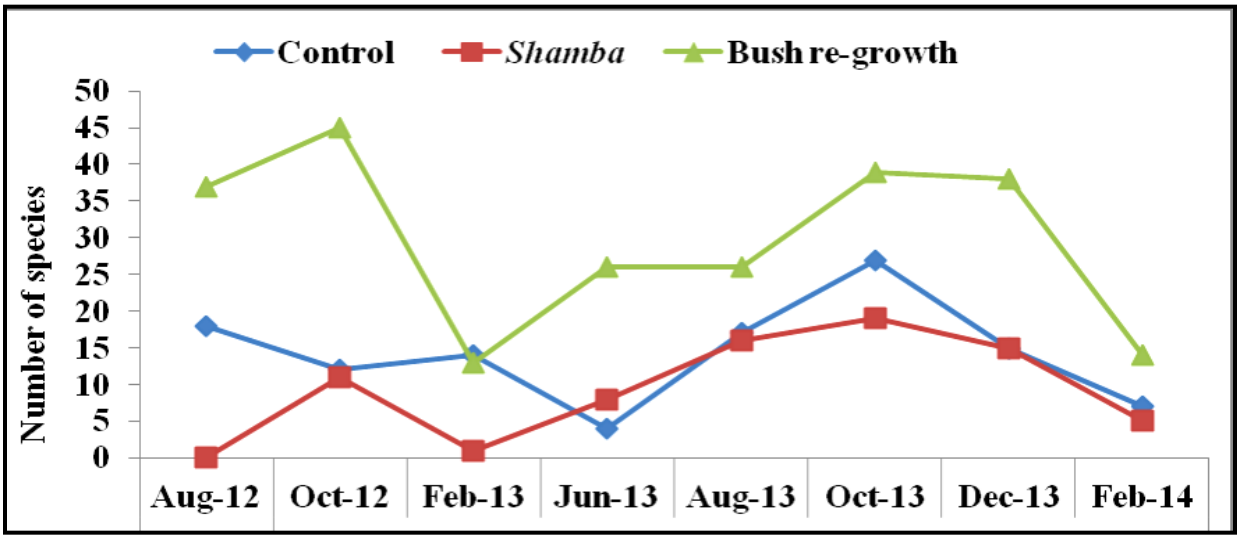

Figure 8: Temporal changes in number of bird species after experimental treatment

DISCUSSION

Bird Species Abundance and Diversity across Sampling Plots

Bird Species Diversity

Failure of the curves to rise to level of plateau in this study indicates that more species of birds could be recorded with further sampling effort**.** It is only after approximately 50 days of field work that the majority of species can be recorded (Bibby *et al.,* 1998). If the curve is extrapolated beyond the data obtained, a prediction of the level at which it reaches a plateau can be made. The level of plateau is equivalent to the total number of species expected at the site (Bibby *et al.,* 1998). However, this method favours highly vocal species such as Tropical Boubou *Laniarius aethiopicus* and Black-backed Puffback *Dryoscopus cubla* that are better identified from their calls than sight unlike the shy and less vocal species (Wamiti *et al.,* 2007).

The overall Shannon-Wiener Diversity Index for pooled data was approximately equal to the Diversity Index in the Bush re-growth plots. The curves however, showed higher number of bird species in Re-growth than in Control and *Shamba* plots**.** In overall, it depicts that with a few exceptions the Bush re-growth plots harboured nearly all bird species observed in the *Shamba* and Control plots. This was due to the fact that most of bird recorded are forest edge species or are those which are insensitive to habitat change. In addition, it was due to lower levels of disturbance and subsequent re-growth of plants in the Bush re-growth plots. Similarly, Kang *et al.* (2015) found that patches with lower levels of human disturbance had higher diversity than newly established patches where intense human activities occurred more frequently. This indicates that, as a result of cessation of human activities, the Bush re-growth plots were attractive to birds due to availability of food, breeding sites, breeding materials and cover from predators (Waterhouse *et al.,* 2002) compared to other categories of plots. On the other hand, the experimental treatment turned the Bush re-growth plots into a complex community, with a greater array of interactions (Brower and Zar, 1984) as compared to *Shamba* and Control. On the contrary, the low numbers of bird species in the *Shamba* and Control plots was a result of continuing human disturbances particularly from agricultural practices which were associated with removal of vegetation. In similar situation, Canady (1997), indicated that biodiversity is greatly affected by human activities, such as agricultural expansion.

Bird Species Abundance

Birds showed a positive response to re-growth of vegetation. The results of the study were consistent with hypothesis that bird species abundance is significantly higher in Bush re-growth than Control and *Shamba* plots. Having taller vegetation than the Control and *Shamba* plots, the abundance of birds in Bush re-growth plots was presumably much higher than that recorded. This is because some cryptic birds can easily be overlooked owing to tall vegetation. Such cryptic species might be more abundant than suggested by the survey (Luikart *et al.,* 2000). In addition, the study on breeding birds of EUM, Moreau (1936), found a large proportion of birds singing more during the breeding season than in the non-breeding season. In EUM, the breeding season extends from the end of August through mid January. This may have contributed to increase in rate of detection of birds due to singing by males (Mkongewa *et al*., 2013), especially between October and December.

Moreover, there was no physical presence of people, animal disturbance, trampling and removal of vegetation in the re-growth plots. Hence, apart from allowing re-growth of plants, there was no disturbance to birds in the re-growth of plants. The re-grown vegetation was a source of food, nesting materials and a complimentary habitat for birds (Smallbone *et al.,* 2013). The low abundance of birds in Control and *Shamba* plots could be attributed to human disturbances particularly clearing of the vegetation. Removal of the vegetation creates edge effect which was more pronounced in the Control and *Shamba* plots than in the Re-growth plots. The edge effects included higher temperatures, sunlight and wind speed as reported by Murcia (2005). Normally, human disturbances cause habitat loss and reduction in the amount of seeds and insects that could attract granivorous and insectivorous birds (Moss, 2005).

The Sørensens similarity index 0.7 (70%) indicated that most of bird species (46) were shared by Bush re-growth and Control plots. This suggests that regardless of differences in floristic composition between the two plot categories, both had resources that could be shared by bird species common to both. For instance, the Common Bulbul and Yellow White-eye were found in both plots. These are forest generalists that can exploit resources of adjoining habitats and may not be affected by forest edges (Kahana *et al.,* 2013).
Insignificant changes in numbers of bird species in Bush re-growth plots between June-August (2013), suggests that some species such as White-tailed Crested Flycatcher and Little Greenbul, were in lower altitudes to avoid cold weather in higher altitude during this season. This trend was similar to that observed by Werema (2007). The found that, other bird species such as Olive Sunbird and Tambourine Dove which were mist netted at lower elevation during cold season, were re-trapped at higher elevation during hot season. On the other hand, the lower number of bird species sampled in Bush re-growth and *Shamba* plots in February 2013 and February, 2014 suggests that in their altitudinal migratory movements, some of the species were at higher altitudes prior to the hot season (Werema, 2007).

Occurrence of LBT in Bush re-growth plots

Failure of *LBT* to occupy the Bush re-growth plots was in one hand possibly caused by *M. eminii* in sampling plots e.g Mlesa, Sangalawe and Kwamkoro. Approximately 45% of the canopy in these plots was covered with this species. This is supported by Borghesio (2012) findings showing that abundance of *M. eminii* negatively correlates with the distribution of and recording rate of *LBT.* Similarly, Borghesio (2012) found lower frequencies of five out of eleven of targeted species of birds in places with higher abundance of

M. eminii. He further predicted a 45% decrease in frequencies of *LBT* in sampling points dominated by this species. On the other hand, the absence supports the hypothesis that the presence of *LBT* rests on delicate equilibrium between vegetation disturbance and re-growth (Borghesio, 2011). The Bush re-growth plots had canopy gaps which are essential to *LBT.* But the plots were not suitable for the species due to absence of sufficient tree climbers and of dense bushy vegetation. The climbers provide cover to the tree's bare trunk and branches, and attract insects. Insects provide additional food for birds (Fottit and Adler, 2009). On the other hand, it appears that more time was needed for *LBT* colonize the plots. This would require further sampling effort over the years. In Malaysia for instance, it took twelve years after logging operation, for seventeen of the twenty two common species that had disappeared following a logging operation to reappear (Johns, 1989). Indeed, the satisfying news is that 50% of the plots were occupied by LBT by 2015-2016, as sampling of these plots continued by the field team after the thesis fieldwork was completed.

The Relationship between Vegetation Height and Bird Species Diversity

The lack of correlation between bird species diversity and height of vegetation could be attributed to tall vegetation that was minimizing the rate of detection of birds, particularly the Understory, skulking and silent ones (Plate 5). This is because detecting and identifying birds while walking in tall vegetation is a challenge (Bibby *et al.,* 2000). It is presumed that observer's movements in tall vegetation could flush the birds even before they were detected. Clearly, noisy and active birds should be easier to detect than cryptic ones (Mollon, 2010). In this study, birds such as the African-Dusky-Flycatchers *Muscicapa adusta* that feed at middle strata and those at forest canopy height were easy to detect. The cryptic species such as Usambara thrush *Turdus roehli* that feed within three metres of the ground level were difficult to be detected. The paradox situation depicted in this study was probably due to presence of *P. aquilinum* and invasion of *Clidemia hirta* and *Lantana camara* which dominate the forest edge areas in EUM (TBA, 2006). *P. aquilinum* is described as a biological hazard of our age as contains different poisonous agents that cause different chronic and acute problems in animal species and humans alike (Vetter, 2007). *C. hirta* produces fruits which may attract frugivorous birds, but it causes loss of diversity of species of plants and other guilds of birds by inhibiting growth of native understory plants. It causes problems to forest regeneration by rapidly colonizing natural light gaps (Kerdkaew *et al.,* 2014). Low diversity of plants caused by *C. hirta* renders the

site unsuitable for arthropods, and plants that would produce fruits/seeds needed by different bird foraging guilds.

Plate 2: Tall vegetation impacting observer's visual ability to detect birds (Nsajigwa, 2013).

The influence of distance of plot to the edge of the forest was reflected in negative weak correlation between vegetation height and bird species diversity in Control plots as well. Similar to the Bush re-growth plots, the Control plots had the same distance from the edge of the forest. The negative correlation in Control plots was possibly induced by recurring presence of humans in the plots during the entire agricultural cycle and the human influence on type of plants. In most cases, human movements and noises are likely to scare birds away, especially the shy ones.

Temporal Changes in Vegetation Height across Study Plots

The height of vegetation in *Shamba* and control plots relied on the season and type of vegetation constituting the highest percentage cover. For instance, *Musa spp* (Banana) were taller than *Phaseolus vulgaris* (Beans). The seasons determined the presence or total absence of crops in some of the plots. For instance, in plots with *Zea mays*, the average height was zero during preparation of farms, maximum during

harvesting period and zero again after harvesting. *Zea mays* is fast growing, short-lived annual crop, growing to 7 m, but more commonly to 2–3 m in height (Moran, 1996). In rainy season, the abandoned *Shamba* and or the Control plots were heavily infested with *Pteridium aquilinum.* The invaded plots were completely devoid of native plant species seemingly owing to allelopathic inhibitory effect of the species on other plants (Gliessman and Muller, 1978). This plant often invades disturbed areas (Crane, 1990). The Vegetation was relatively taller in Bush re-growth than Control and the *Shamba* plots. The changes in average height of vegetation in Bush re-growth plots were attributed to some extent by heights of *Clidemia hirta* and *P. Aquilinum.* These plants are dominant in the forest edges within EUM (Verdcourt, 1952). For instance, in its life cycle*,* the fronds and the body of the *P. aquilinum* visible above ground, die each year, crushing the underlying plant life (Crouch, 1974). *P. aquilinum* measures up to 2 m in other parts of the world (Whitehead, 1993). In EUM it is as tall as 3.4 m, with maximum and minimum heights in rainy and dry seasons, respectively.

The Bush re-growth plots were also invaded by *C. hirta*, *Rubus spp* and *P. aquilinum*. Apart from problems arising from invasion, the response of native vegetation to cessation of human activities varied from one plot to another depending on type of invasive species and the severity of invasion. The damages caused by *C. hirta* such as modification of successional patterns and formation of monoculture stands were observed to alter the process of vegetation re-generation (Lowe *et al.,* 2000). For instance, the native plant species were not able to grow in sampling points covered by *C. hirta* in Mlesa, Sangalawe and Emau. Thus, the average height of plants in invaded sampling points was influenced by heights of *C. hirta*. This plant forms a densely-branched perennial shrub up to 5 m tall but normally between 0.5 and 3 m (De Walt, 1994: Binggeli, 2005). The plant produces fruits which are eaten by frugivorous bird species, but it inhibits re-growth of native plants which would attract invertebrates which provide food for insectivorous birds.

Temporal Changes in Half Disappearance Distances across Study Plots

Invariable half disappearance distance in the Bush re-growth plots was a result of cessation of human activities. The cessation allowed re-growth of vegetation to levels that could not show significant changes among successive sampling periods. However, there were similarities in dynamics of temporal variations in half disappearance distance in *Shamba* and Control plots. These variations were driven by similar factors

such as intensity and timing of human activities. In both, there was a recurring removal of vegetation following cultivation and harvesting seasons. Bird species such as Speckled Mousebird *Colius striatus*, were easily detected in sites with higher half disappearance distances i.e. Control and *Shamba* plots. Presumably, it was because these species are not sensitive to human disturbances. Generally, removal of vegetation increased the rate of detection of nectarivore and the frugivore bird guilds. However, the granivore and the insectivore guilds were not observed owing to their sensitivity to human disturbances (Mansor *et al.,* 2012).

The temporal variations in half disappearance distance was dependent on variations in height of vegetation in a given plot category. Thus, the higher the average heights of vegetation, the shorter the chequared board half disappearance distances and vice versa. In general, the changes in half disappearance distances in Control and *Shamba* plots varied with farming seasons and type of vegetation in a given plot. For instance, plots dominated with *T. andersonii* showed significant changes in disappearance distance between successive sampling periods, especially before and after harvesting. On the contrary, plot dominated by the *Z. mays* would show highest disappearance distance during planting and lowest close or during harvesting period. The response of birds to temporal variations in half disappearance distance in *Shamba* and Control plots is depicted by distribution of species among three plot categories. Birds such as Common Bulbul, Fischer's Turaco Collared Sunbird and Fork-tailed Drongo were spotted in all categories of plots. This indicated that they were not sensitive to variations in half disappearance distances i.e. vegetation density. However, species such as Pale-breasted Illadopsis were restricted to Bush re-growth plots only. This shows that these birds are negatively impacted by human disturbances occurring in *Shamba* and Control plots.

Plant Species with Highest Performance

Plants with highest performance were those forming the first and second highest percentag**e** covers. Plot owner's had no influence on first and second highest performing plants in the Bush re-growth plots i.e. *Clidemia hirta, Solanum robustum, Lantana camara, P. aquilinum* and *R. rosifolius.* However, the influence of owners was seen in the Control and *Shamba* plots i.e. for food crops such as *Manihot esculenta, Saccharum officinarum and Musa spp.* In these plots, the owners were free to plant the types of plants of their own choices regardless of the category of the plot under treatment. In a numbers of cases, the

owners, for unknown reasons, would abandon either the Control or *Shamba* or both. After abandonment, the plots would be invaded by *P. aquilinum* or *C. hirta*. The two plants would form the first and second highest percent plant covers consistent with Hall *et al.,* (2010). The seed bank has been considered an important factor in the regeneration of communities after either natural or anthropogenic disturbance (Quintana-Ascencio *et al*., 1996). Thus, growth of plants in Bush re-growth plots depended, in part, on the seed bank that remained in the soil until favorable conditions for germination and growth occurred (Dalling *et al*., 1998). The native plants that grew included climbers such as *Peponium vogelii* and *Cissus oliveri*.

Cessation of human activities in a number of vegetation re-growth plots on the other hand, enhanced the growth of *C. hirta P. aquilinum* and *M. eminii* which negatively impacted the re-growth of native species of plants. In Mlesa for instance, the saplings of *M. eminii* were not removed at the beginning of sampling. These grew to approximately 10 m in height at the end of sampling period, covering approximately 80% of the canopy. In these plots, the understory was entirely covered with *C. hirta.* Like in other parts of the world, *C. hirta* grew and spread very quickly by producing many seeds and displaced plants (that can tolerate shaded habitats) and inhibited growth of native vegetation.

Crops such as *M. esculenta* do not produce flowers, nectar, fruits or seeds. Thus, they do not make a site favorable for birds. For that matter, they are neither attractive to nectarivores, insectivore, frugivore nor granivore bird feeding guilds. This explains the low abundance and diversity of bird species in Control and *Shamba* plots dominated by these plants. The cessation of human activities further enhanced the growth of natural vegetation comprising of climbers (such as *Cissus oliveri and Peponium vogelii*) and bushes (such as *Streptocarpous glandulosissimus*). Nectar, flowers, seeds, fruits and nesting sites produced by these plants are attractive to birds of different ecological requirements. These may have contributed to higher diversity and abundance of birds in the Bush re-growth plots.

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