Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 12	No. 2	pp. 321-324	2013

Original Research Paper

Impact of Forest Structure Simplification on Bird Species Richness in the Harena Forest of the Bale Mountains National Park (BMNP), South Eastern Ethiopia

Anteneh Shimelis*, Mitchell Pinard and Addisu Asefa*****
*****Freelance Consultant, Addis Ababa, Ethiopia
******University of Aberdeen, Scotland, U.K.
*******Bale Mountains National Park, Robe, Ethiopia

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com
Received: 19-7-2012
Accepted: 12-9-2012

Key Words:
Bird species richness
Habitat structure
Habitat simplification
Harena forest
Tree cutting

ABSTRACT

Human simplification of habitat in the Harenna forest mainly happens by permanently removing woody vegetation. We evaluated the impact of such simplification of habitat on bird species richness. Birds were counted using the point count method at points that were laid out along transect lines, and from their presence/absence, species richness was worked out. By establishing 50m by 50m quadrats at bird counting stations, we counted the number of basal remnants of cut trees and we measured vegetation structure variables such as % grass, % other herbs, % shrubs, % bush and % canopy (tree cover). Tree, bush and shrub covers did have significant positive correlation with bird species richness. As the magnitude of tree cutting increased species richness of birds declined significantly. Similarly with bird species richness, structural variables such as tree, bush and shrub covers did have significant negative correlation with the tree cutting variable. Due to this, we carried out Principal Component Analysis and the first component that was influenced mainly by tree cover and tree cutting variables significantly explained 84.7 % of the variation in bird species richness in a stepwise multiple regression analysis. Bush and shrub cover did also have significant positive contributions towards the explanatory value of the first component, thus, their positive contribution in explaining bird species richness is noteworthy. Results showed habitat simplification through tree cutting has significant negative impact on bird species richness.

INTRODUCTION

Structurally complex habitat under natural conditions provides a higher level of niche space for animals and accommodates diverse ways of exploitation of the natural environment resulting in increased species richness (Tews et al. 2004). In most habitats plant communities determine the physical physiognomy of the environment, and therefore, have a considerable influence on the distributions and interactions of animal species. For bird species diversity in a forest, MacArthur & MacArthur (1961) indicated that the vertical physical structure of plant communities is of paramount importance. A change in a forest continuum as a result of various modes of human abusive utilization affects the abundance and diversity of plants and animals (Stouffer & Bierregaard 1995). Studies carried out in North America indicated that forest specialist birds suffer the most as a result of human induced fragmentation of forest habitat that significantly reduces their narrow breeding and foraging niche space.

The Bale Mountains represent the relatively pristine features of the Ethiopian highlands constituting a mosaic of landscapes rich in biodiversity. The site is a very important watershed for a larger part of the Horn of Africa and provides the resource base for the livelihood of millions of people (Hillman 1986, Williams et al. 2004, BMNP 2007). This is mainly a result of the rich biological assemblage and interactions that sustain it. The bird assemblage in the Bale Mountains represents a major component of this rich biological assemblage and the area is recognized by BirdLife International as one of the most important bird conservation areas in Africa (EWNHS 1996). Despite the livelihood and conservation values of the site, its biodiversity is being lost at an alarming rate (Hillman 1986, Williams et al. 2004, BMNP 2007). The most important threats to biodiversity in general and birds in particular include farming, tree cutting, and grazing by livestock. Due to increase in human population, that exacerbated problems related to shortage of land and other important resources, the loss of biodiversity is continuing unabated. Except for very few components of the biodiversity in the Bale Mountains, most of the compiled information is not more than a list of species (Stephens et al. 2001, Assefa 2006). In this paper we evaluate the impact of forest habitat structure and its simplification on bird species richness of the Harena Forest in the Bale Mountains National Park.

MATERIALS AND METHODS

Study area: The Bale Mountains National Park (BMNP) is situated (6°30’-7°00' N, 39°30'-39°55’ E) in the southeast high lands of Ethiopia. It encompasses an area of 2200 km^2. The area contains a landscape ranging from 1500m to 4377m above sea level. The soils are mainly derived from the basaltic and trachytic parent rocks (Hillman 1986, Miehe & Miehe 1994). Five vegetation zones are analysed in this National park: the Northern grassland (Gaysay), the Northern woodlands, Ericaceous forest, the Afro alpine moor land and grassland and the Southern Harena forest. Seventy-eight mammal and 282 bird species, of which 17 and 6 of them, respectively, are endemics, have been recorded for the National Park (BMNP 2007). The area experiences two rainy seasons: heavy rain and small rain. The heavy rain is from July to October, with the highest peak in August and the small rain from March to June, with the highest peak in April. Records show that this area experiences temperature extremities during the dry season and more or less the same pattern of warm temperature during the wet season. The highest temperature is 18.4°C in February and the lowest is 1.4°C in January (Hillman 1986).

The present study was conducted in the Harenna forest, located in the southern slope of the Bale Mountains. It covers an area of 7000 km^2 of which 14% (ca. 1000km^2) is included in the BMNP. The vegetation of the forest has been studied mainly focusing on floristic composition and physiognomy. The forest portion belonging to the BMNP, extending between altitudes of 1500 to 3200 m asl, has five vegetation zones along an altitudinal gradient; *Ocotea-Olea-Podocarpus-Syzygium* type (1500-1700 m asl, *Syzygium-Polycios-Allophylus-Erythrina* (1700-2100 m asl), *Schefflera-Hagenia-Erythrina* (2100-2700 m asl), *Hagenia-Hypericum-Shefflera-Myrsine* (2700-3000 m asl) and *Erica arborea* trees (3000-3200 m asl).

Counting Birds

We counted birds using the point count technique (Bibby et al. 1992). Samples were taken in all vegetation zones of the Harenna forest. Ten 2.5 km stretches of transects were put down perpendicular to the Senete-Dolo highway each containing a minimum of 10 points. This was done by ensuring the existence of a minimum of 250 m distance between any two points. At a point, a count lasted for 8 minutes in addition to the three minutes provided for the birds to get used to the presence of census personnel before a count commenced. Birds were identified and counted visually and vocally. Records were made in two bands by establishing a 25 m radius from the central point of a counting station. Counts in all points were made by the same individual in the morning between 6 and 12 a.m.

Habitat Assessment

By setting up 50 m × 50 m quadrats in each of the bird counting plots, the proportion of habitat structural parameters that included tree (canopy layer), bush (mid canopy layer), shrub (under storey layer), grass, and other herbs were estimated. As a measure of human impact that simplified the forest habitat basal remnants of cut trees were counted in the 50 m × 50 m quadrats.

Data Analysis

Simple correlation analysis was carried out to explore potential relationships and as result of some level of coliniarity amongst predictor variables Principal Component Analysis was carried out prior to undertaking a stepwise multiple regression analysis.

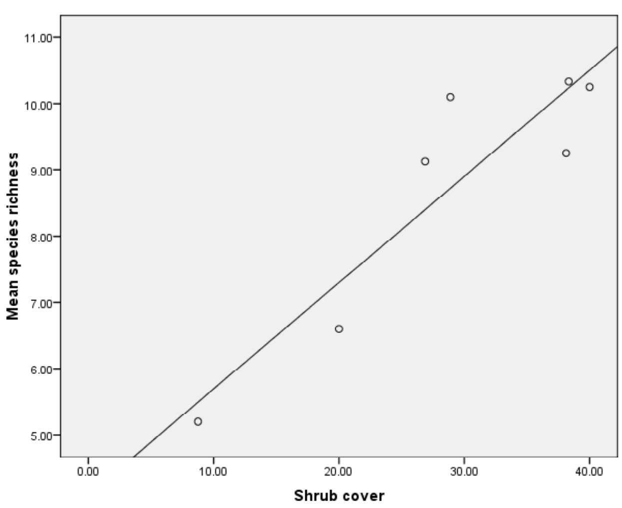

Fig. 1: Correlation between mean bird species richness and percentage of shrub cover (r = 0.91, P = 0.004).

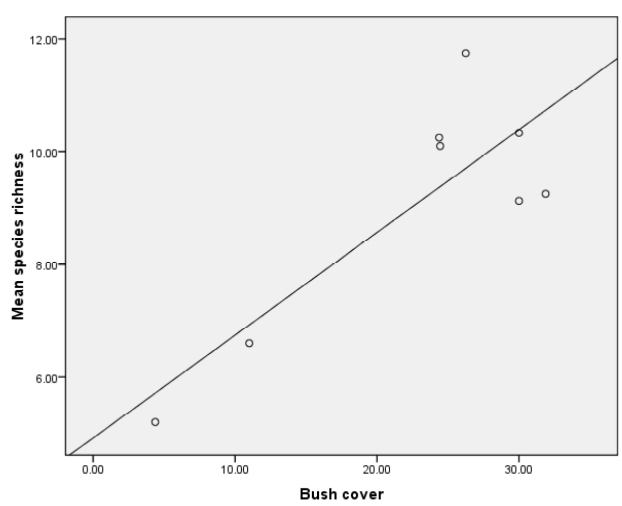

Fig. 2: Correlation between Bush cover in the forest with species richness of birds (r = 0.84, P = 0.009).

Table 1: Correlation matrix amongst variables that were predictors of bird species richness spatially.

	Tree remains	basal	Tree cover		Bush cover	
	r	P	r	p	r	P
Tree cover	-0.88	0.002				
Bush cover	-0.81	0.008	0.43	0.29		
Shrub cover	-0.8	0.018	0.54	0.21	0.63	0.09

Table 2: Component loadings of predictor variables that resulted from Principal Component Analysis

Predictor	C1	C2	C3
Tree basal remains	-0.95	0.08	0.25
Tree cover	0.93	0.07	-0.34
Bush cover	0.69	-0.6	0.4
Shrub cover	0.68	0.6	0.39

RESULTS

Where shrub cover was small the magnitude of bird species richness was low and it increased significantly (Fig. 1) with increased presence of shrubs in the forest habitat. Similarly increased bush cover in patches resulted in significantly high number of bird species (Fig. 2). Species richness of the bird community increased significantly as the tree cover increased across samples (Fig. 3). Mean number of basal remains of cut trees had significant negative correlation with the number of bird species observed across point samples (Fig. 4). With increases in this measure of habitat simplification which is the intensity of tree cutting that was measured as the number of basal remnants of trees that were cut, the species richness of birds of the forest did decline.

Variables that were correlated significantly with bird species richness were evaluated for coliniarity. Although measures of habitat structure were not correlated with each other, their magnitudes declined significantly as a result of tree cutting showing this variable was a major force of habitat simplification caused by human beings (Table 1).

As a result of the observed coliniarity amongst predictor variables Principal Component Analysis (PCA) was carried out. The first three components were extracted in this data reduction exercise and the amount of variability explained declined in an ascending order. The first component that explained 67.6 % of the variation was heavily the result of influence of measures tree cutting and tree cover that are positioned at opposing extreme points of the axis (Table 2). Bush and shrub covers did also have significant contribution towards the explanatory value of this component. The second component was defined by bush and shrub covers. With regard to component 3 that explained about 12 % of the variation in the data set, none of the predictor variables had significant defining influence.

To explain the spatial variability in species richness the resulting component axes were subjected to a stepwise multiple regression analysis. This selected the first PCA component as a significant predictor ($F = 22.2$, $P = 0.009$) explaining 84.7 % of the variation in the data set. The slope of the best fit model was 1.2 at $P = 0.009$. This showed tree cover and habitat simplification are the two most important variables in explaining spatial variations in bird species richness in the forest.

DISCUSSION

Agriculture, urbanization and other human activities have significantly modified habitats of many species of plants and animals at different landscapes (Dorp & Opdam 1987, Gascon et al. 1999). These activities by humans that remove biological components of a forest permanently have resulted in isolation of wooded habitats in rural temperate environments and fragmentation of virgin forests in places like Amazonia. It was demonstrated that such human transformation of habitat does have significant negative effect on diversity and other attributes of bird communities (Lawton et al. 1998, Gascon et al. 1999, Stouffer & Bierregaard 1995, Schulze et al. 2004).

Species numbers decline because species disappear from patches where permanent removal of forest components destroyed their foraging and nesting resources and due to unnaturally enhanced exposure to natural enemies such as predators. Permanent removal of forest components also destabilize the balance of processes such as interspecific competitive co-existence changing the magnitude of species richness and composition as well.

Increases in bird species numbers occur in typically natural structurally complex systems where there is high density and diversity of foliage that strongly affects the magnitude of the available foraging and breeding niche space (MacArthur & MacArthur 1961, MacArthur et al. 1962, Karr 1968, Karr & Roth 1971, Cody 1974, Wilson 1974, Martin 1988). Simplification of the natural complexity of habitat results in local disappearance of species causing spatial decline in species richness along a gradient of tree cutting such as the results documented in this paper.

In the Harena forest it is common place to find transformation of primary habitats as result of illegal agricultural expansion and tree cutting, shrub and bush clearance for on-site and off-site uses (Assefa & Shimelis *pers. comm.*). This was confirmed as we were carrying out surveys for this study. The forest is home to endemic, globally threatened and biome

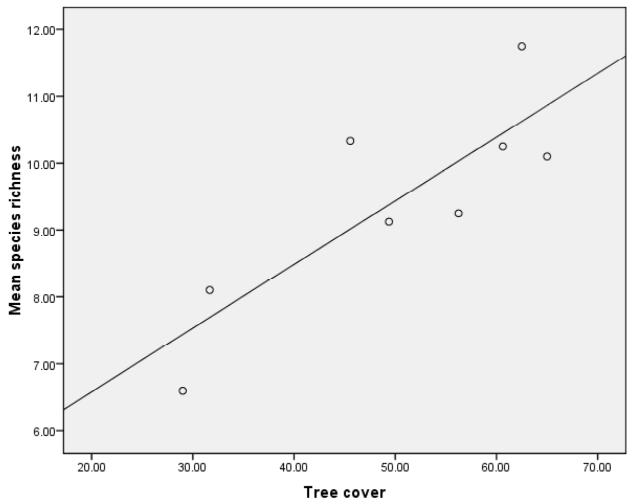

Fig. 3: Correlation between bird species richness and percent tree cover (r = 0.84, P = 0.01).

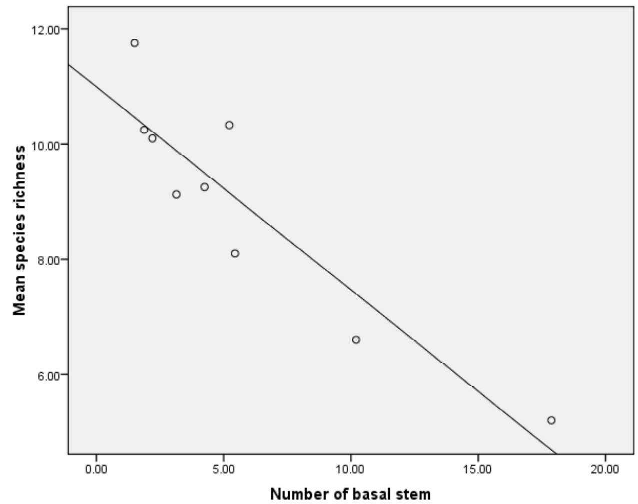

Fig. 4: Correlation between the basal remains of cut trees with bird species richness (r = -0.91, P = 0.001).

restricted species (EWNHS 1996) and as important as this it is a major watershed from which several rivers that are important water sources to the horn of Africa originate. The human induced simplification of habitat is a major threat to birds, as was shown in our results and if the destruction continues unabated it will destabilize the hydrology of the horn region. It is thus very important to take legal action alongside environmental awareness and education initiatives to change the negative trend observed and documented in our study.

ACKNOWLEDGEMENT

This research was funded by the Darwin Initiative and the Ethiopian Wildlife Conservation Authority provided research permit.

REFERENCES

Bibby, J.C., Burgess, D.N. and Hill, A. D. 1992. Bird Census Techniques. Academic Press, London.

BMNP 2007. Bale Mountains National Park: General Management Plan (2007-2017). Ormia Agriculture and Rural Development Bureau. Addis Ababa, Ethiopia.

Cody, M.L. 1974. Competition and the Structure of Bird Communities. Princeton University Press, Princeton, New Jersey, USA.

Dorp, D. and Opdam, P.F.M. 1987. Effects of patch size, isolation and regional abundance on forest bird communities. Landscape Ecology 1: 59-73.

EWNHS 1996. Important Bird Areas of Ethiopia. Ethiopian Wildlife and Natural History Society.

Gascon, C., Lovejoy, T.E., Bierregaard, R.O., Malcolm, J.R., Stouffer, P.C., Vasconcelos, H.L., Lawrance, W.F., Zimmerman, B., Tocher, M. and Borges, S. 1999. Matrix habitat and species richness in tropical forest remnants. Biological Conservation, 91: 223-229.

Hillman, J.C. 1986. Bale Mountains National Park Management Plan. Ethiopian Wildlife Conservation Organization, Addis Ababa, Ethiopia.

Karr, J.R. 1968. Habitat and avian diversity on strip-mined land in east central Illinois. Condor, 70: 348-357.

Karr, J.R. and Roth, R.R. 1971. Vegetation structure and avian diversity in several New World areas. American Naturalist, 105: 423-435.

Lawton, J.H., Bignell, D.E., Bolton, B., Bloemers, G.F., Eggleton, P., Hammond, P.M., Hodda, M., Holts, R.D., Larsen, T.B., Madsley, N.A., Stork, E.N., Srivastava, D.S. and Watt, A.D. 1998. Biodiversity inventories, indicator taxa and effects of habitat modification in tropical forest. Nature, 39: 72-75.

MacArthur, R.H. and MacArthur, J.W. 1961. On bird species diversity. Ecology, 42: 594-598.

MacArthur, R.H., MacArthur, J.W. and Preer, J. 1962. On bird species diversity. II. Prediction of bird census from habitat measurements. American Naturalist, 96: 167-174.

Martin, T.E. 1988. Habitat and area effects on forest bird assemblages: Is nest predation an influence? Ecology, 1: 74-84.

Miehe, G. and Miehe, S. 1994. Ericaceous forest and heath land in the Bale Mountains of South Ethiopia. Ecology and Man's Impact. Traut Warnke Verlag, Hamburg.

Schulze, C., Waltert, M., Kessler, P.A.J., Pitopang, R., Shahabuddin, Vehedler, D., Mühlenberg, M., Gradstein R., Leuschner, C., Sttefan-Dwenter, I. and Tscharntke, T. 2004. Biodiversity indicator groups of tropical landuse-system: Comparing plants, birds and insects. Ecological Applications, 14(5): 1321-1333.

Stouffer, C.P. and Bierregaard, R.O. 1995. Use of Amazonian forest fragments by understory insectivorous birds. Ecology, 76: 2429-2445.

Tews, J., Brose, U., Grimm, V., Tielbörger, K., Wichmann, M.C., Shwager, M. and Jeltsch, F. 2004. Animal species diversity driven by habitat heterogeneity/diversity: The importance of keystone structures. Journal of Biogeography, 31: 79-92.

Wilson, M.F. 1974. Avian community organization and habitat structure. Ecology, 55: 1017-1029.