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Urban Sprawl Effects on Biodiversity in Peripheral Agricultural Lands in Calabar, Nigeria

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Abstract
The main objective of the paper is to determine the effects of urban sprawl on biodiversity in peripheral lands in Calabar, Nigeria. The specific objectives of the study are: To examine the effects of farm size and farm density on selected species in peripheral agricultural lands such as birds, butterflies and bumblebees and to compare faunal diversity on farmlands within sprawl (FLWS) and farmlands outside sprawl (FLOS) areas. 20 farms were sampled for the study, 10 in FLWS and 10 in FLOS. The relationship between farm size, tree diversity and diversity of avian fauna (birds) on agricultural lands was tested with multiple correlation analysis. Result of the analysis revealed that FLOS had more butterfly diversity with 42 (62.69 per cent) than FLWS with 25 (37.31 per cent). It was also observed that the joint contribution of the two independent variables to the variance of bird species in agricultural lands is positive with multiple correlation coefficient value of r = 0.50. This r value is significant, implying that there is a significant relationship between farm size, tree diversity and the diversity of avian fauna in agricultural lands. This finding implies that species diversity in agricultural lands are declining while others, such as those in the Satyridae family are in danger of becoming extinct due to encroaching sprawl development. It is therefore, recommended that eco-farming techniqus such as the cultivation of specific plants that attract pollinators such as Ranvolfia volmitoria be integrated into farmlands.

Key words: Agricultural, Biodiversity, Peripheral, Urban sprawl

Introduction

Urban sprawl is one of the most challenging threats to biodiversity in the world today. Sprawl is a form of development that typically occur in cyclical bands surrounding large urban centres. Often times urban sprawl development originate as disconnected developments and single family homes established outside urban areas well beyond city limits but usually within commuting distance to the city centre. Over time, the areas between the disconnected settlements and the urban centre begin to be filled with residences, large ware outlets and other businesses, parking lots and manicured lawns until a dense suburb is created. This newly developed areas have been called "peri urban areas" (Imhoff, 2000), the "inter-metropolitan periphery" (Berry, 1990), and the "exurban areas" beyond the suburbs called "fringe development" (Daniel, 1999) and "extendend places" Bureau of the Census 2000) are all referred to as sprawl areas (Atu, Offiong, Eni, Eja & Esien 2012)

Thus, urban sprawl involves the conversion of open space, wetland, semi natural and natural vegetation and agricultural land into built up developed land, therefore, the development of urban sprawl is not without consequences on the native biota since land cover is positively correlated with species endemism, (Myers, Mittermeir, Mittermer, Fonseca & Kent 2000). Hence, sprawl development threatens biodiversity directly through habitat loss and indirectly through habitat fragmentation, degradation and homogenization of the native biota.

The development of urban sprawl is linked to urban and suburban decline as economic activities move from inner city region to Greenfield development sites at the suburbs. These Greenfield sites frequently offer lower construction cost in the initial stages of development. The movement to new location is associated with population growth, advances in transportation technology, and policies governing housing and infrastructure (Mum, 1956).

Recently, in Calabar, 2002-2012, there has been outgrowth of Greenfield residences on the urban periphery developed by the government, and the private sector for their workers or by property developers for rent or sale. These development is consequent on the growth of the population of Calabar as a result of its new status as the tourism/leisure destination of West Africa. This change in the size of the population and status of the city implies pressure on agricultural lands and biodiversity because peripheral agricultural lands are converted to sprawl development in order to accommodate the rapidly increasing urban population while the remaining agricultural lands are worked more intensively to feed the immediate needs of the large urban population.

Prior to the recent sprawl development, the peripheral agricultural lands in Calabar are areas of high species diversity, but, as these areas are modified, numerous species are declining such as *Egretta garzetta, Little egretta, Bostrycgia* hagadash and *Streptopelia decipiens*. This is due to the fact that most species that have adapted to agricultural lands require methods of non-intensive habitat management for their survival. Therefore, the conversion of such farmed environment to urban sprawl is a threat to the rich fauna of these areas.

Incidentally, agricultural lands and biodiversity are often considered to be mutually exclusive, hence, studies on sprawl impacts on biodiversity are limited to the effects of urbanization on the environment (Kolankiewicz and beck 2002);sprawl effects on agricultural land (Yohannes, 2002; Lopez', Mitchell and Thomlinson 2001). Inspite of these studies, the relationship between urban sprawl, loss of agricultural lands and the decline of biodiversity, specifically, birds, butterflies and bumblebees has not garnered much attention in scientific researches. It is this perceived limitation in scientific researches that this paper sought to study the effects of biodiversity in peripheral agricultural lands in Calabar, Nigeria. It is based on the above that we asked the questions: is there a difference in the diversity of species (birds, butterflies and bumblebees) between agricultural lands impacted by sprawl and agricultural lands un-impacted and is there a difference in the diversity existing within agricultural lands, that is, birds, butterflies and bumblebees among the different sprawl formations and hypothesized that there is no significant relationship between farm size, tree diversity and the diversity of avian fauna in agricultural lands.

Objectives

The main objective of the paper is to determine urban sprawl effects on biodiversity in peripheral agricultural lands in Calabar, Nigeria. And the specific objectives are:

1. To examine the effects of farm size and farm density on selected species in peripheral agricultural lands such as birds, butterflies and bumblebees.
2. To compare faunal diversity on farmlands within sprawl (FLWS) and farmlands outside sprawl (FLOS) areas.

Literature

The decline in biodiversity as a result of the reduction and modification of agricultural lands has been documented as evidence in the literature. This is because sprawl encroachment into peripheral agricultural lands results in the loss of fertile land. Farmers, therefore, need to enhance the fertility of the land by adding fertilizer, changing to new farm techniques or changing to more productive crops. This change in prior farming techniques will definitely change the constitution of biodiversity that has adapted to the former farm management. For instance Belfrage, Bjorklund and Salomonsson (2005) in their study on the 'effects of farm size and organic farming on the diversity of birds, pollinators and plants in a Swedish landscape' discovered that more than twice as many bird species, butterflies, herbaceous plant species and five times more bumblebees were found on the small organic compared to the large conventional farms. The authors argued that altered management practice such as monocultures and intensification of agriculture has influenced the number and demography of birds. This is in line with the findings of Beecher, Johnson, Brandle, Case and Young (2002); where bird abundance in organic sites were found to be more than two times higher than non -organic sites (that use fertilizer and herbicides).

In a similarly study, Luoto, Seppo, Jyrki and Juha (2003) linked agricultural production changes to landscape fragmentation and species diversity. Based on their study on 'the loss of plant species richness and habitat connectivity in grasslands associated with agricultural change in Finland', they argued that development in agricultural production drives land-use changes and thus controls the capacity of landscapes to maintain biodiversity. Hansen, Knight, Marzluff, Powell, Brown, Gude and Jones (2005) also asserted that land use and land cover change due to sprawl is the primary cause of biodiversity loss in the world. While Riley, Gary, Lee, Thomas, Lena, Rosi, Jacob, Robert and Sauvajot (2005) attributed the decline of mammalian carnivores to urbanization (sprawl) and fragmentation. This assertion was made based on the outcome of their research on 'effects of urbanization and habitat fragmentation on Bobcats and Coyotes in Southern California' where urban areas were found to be less suitable in significant ways. Riley, et.al (2005) studied the ecology of bobcats (*Lynx rufus)* and coyotes (*Canis latrans*) relative to development in a fragmented landscape in southern California from 1996 to 2000. 50 bobcats and 86 coyotes were captured and radiocollared. The home ranges for 35 bobcats and 40 coyotes were determined and their exposures to urban association were measured. Their findings show that even the few animals that had almost no human development within their home range were vulnerable to human related mortality.

In view of these assertions (Forys and Allen 2005) explored the relationship between sprawl and biodiversity using a data set of ants species collected from forty six habitat patches located in the increasingly urbanized Florida Keys in a study on, 'The Impacts of Sprawl on Biodiversity: the Ant Fauna of the Lower Florida Keys'. They quantified sprawl as the proximity of roads and amount of development surrounding a habitat patch. Bait transect was used to identify 24 native and 18 non- native species of ants. Their findings show that neither the overall number of native species nor the number of rare species was significantly correlated with the amount of development. They concluded that the native ant fauna of the Florida Keys does not appear to be dramatically influenced by sprawl. However, they conceded that if development increases, the number of non native ants may increase and many of these will decrease the native ant diversity. Based on the study it can be concluded that sprawl is a precursor to the introduction of invasive species in an ecosystem. This will eventually lead to the decline and loss of native species. The work of Riley et. al., (2005) in Southern California Streams, contradicts the findings of Forys and Allen (2005), by showing that urbanization was significantly correlated with alteration of stream habitat and the introduction of invasive species. Riley, et. al (2005) also researched on the ‘effects of urbanization on the distribution and abundance of amphibians and invasive species in southern California streams’. They determined the distribution and abundance of native amphibians and exotic predators and characterized stream habitat and invertebrate communities in 35 streams in an urbanized landscape north of Los Angeles. Watershed development was measured as the percentage of area within each watershed occupied by urban land uses. Streams in more developed watersheds had more exotic crayfish (*Procambarus clarkii*) and fish and had fewer native species such as California newts (*Taricha torosa*) and California tree frog (*Hyla cadaverina*) whose effects seemed particularly evident above 8 per cent development. They thus, concluded that urbanization has significantly altered stream habitat in the region which may enhance invasion by exotic species and negatively affect diversity and abundance of native amphibians.

In another study on the European tree frog (*Hyla arborea*) in an agricultural landscape in Western Switzerland, (Pellet, et. al. 2004) used a robust concentric approach based on permutation to evaluate the impact of urbanization (sprawl) on the presence of the endangered tree frog in wetlands. The frequency of 1 traffic and 14 land use indices at 20 circular ranges (from 100m up to 2 km radii) around 76 ponds identified in western Switzerland were analyzed. Their findings differ significantly from those of (Forys and Allen 2005) by indicating that urban areas and road surfaces had a strong adverse effect on tree frog presence even at relatively great distances (100m-1km). This implies that sprawl and traffic must be considered when pond creation is an option in conservation management plans as is the case for the European tree frog in Switzerland. Markovchick- Nicholls, Regan, Deutschman, Martin, Noreke and Hunt (2008) looked at ‘relationships between human disturbance and wildlife land- use in urban habitat fragments’ by tracking data (animal tracts and den or bed sites) on 10 animal species and information on human activity and environmental factors associated with anthropogenic disturbance in 12 habitat fragments across San Diego County, California. They examined the relationship among habitat fragment characteristics, human activities and wildlife presence. No significant correlations of species presence and abundance with per cent plant cover for all species or with different land use intensities for all species except the oppssum (*Didelphis virginiana*), which preferred areas with intensive development was found. Their result indicates that maintenance of habitat fragments in the form of farmlands is conservation benefit to some animal species despite human activity and disturbance as long as the fragments are large. Waltert, Mardiastuti and Muhlenberg (2004) findings differ significantly from those of Markovchick-Nicholls,et. al. (2008) by showing that species richness decreased from natural forest and young secondary to agro forestry systems and annual cultures. Although species richness was similar between natural and young secondary forest, the number of endemic birds’ species was significantly lower in second growth forest. Specifically, species composition gradually changed as the habitat changed from natural to secondary forest to agroforestry systems and annual cultures despite the proximity of the farms to near primary forest, the agro forestry supported only a few small frugivorous-nectarivorous species.

For Bell and Irwin (2002) sprawl is more a time dependent process that results in particular sprawling spatial distribution that is visible at varying spatial scale. Human settlement is usually biased toward resource rich areas resulting in clustered spatial distributions. Agreeing with (Bell and Irwin 2002), Theobald (2003) pointed out that settlement pattern are highly clustered around important resources. Hence as settlement expands with time the general level of human activity at broader scales increases and human influence grows throughout the landscape by selecting more biologically rich habitat and fragmenting landscapes thereby increasing conflicts with biodiversity.

The sprawl process according to Brown and Laband (2006) leads to higher levels of human activity at broader spatial scales hence higher levels of impact on biodiversity. Brown and Laband (2006) also asserted that it is the degree of activity and not variation in spatial distribution of activities that best explains the variation in the proportion of endangering of native species. Hence the degree to which settlements cluster or diffuse human distribution is not related to the percentage of endangered species in an area when human activity levels remain constant. In response to (Brown and Laband 2006), Baldwin, Ray, Trombulak and Woolmer (2007) agreed that higher levels of activity inside any unit will lead to a greater conflict with biodiversity but disagree with their conclusion that the patterns and process of sprawl is not a leading cause of species imperilment.

Methodology

The types of data acquired for the study include: data on the spatial extent of farm lands within sprawl (FLWS) and farmlands outside sprawl (FLOS) areas, farm sizes (FS) of farm lands, distance between patchesm that is density (FD) of FLWS and FLOS and proximity of farm lands to built- up areas. The total number and types of cultivated crops and tree species on FLWS and FLOS were collected. Inventories of pollinators' diversity (butterfly and bumblebees) and birds were also collected for the study. Field observation, measurement and counting by the researcher was the main source of data for birds, butterflies and bumblebees inventory, number and patch sizes of agricultural land, proximity of agricultural lands to built -up areas and the types of crops cultivated. Data on the spatial extent of agricultural land was extracted from Landsat ETM 1980 and SPOT Image of Calabar 2012. These data sets were sourced from National Centre for Remote Sensing (NCRS) Jos, and the GIS Laboratory Department of Geography and Regional Planning, University of Calabar, Calabar. Other sources of information utilized for the study include journals, text books, dissertation on relevant study areas and the internet which were sourced for literature and theoretical framework for the study.

A reconnaissance survey of the study area was undertaken from 3rd -7th March, 2012 to determine farmlands within and outside sprawl areas. The reconnaissance survey also created opportunities for determining access points to the farms, line transect location, and obtaining permission from the farmers to use their farms for the study. Samples were collected from the identified farms from May 14th - August 14th 2012 (which is the peak of the farming season). Field measurement of farm sizes, farm density and the distance of the farms to built- up areas within and outside sprawl areas were done by the researcher with two assistants with the aid of a metric tape. This is to determine if sprawl has an effect on farm size and crop types which were related to the diversity of birds, butterflies and bumblebees. The butterflies and bumblebees were collected using baits made up of banana and table salt placed at sampled points (two each of agricultural lands within sprawl and agricultural lands outside sprawl). Butterflies and bumblebees that were attracted to the baits were collected using sweep nets as well as those on reproductive parts of plants and placed in a killing jar containing cotton wool and chloroform to immobilize them. They were then collected with fine forceps into labeled sample bottles and conveyed to the laboratory for identification. Identification of the butterflies and bumblebees was done using Boorman's (1991) method and confirmed with paratypes identified in British museum and kept in the department of Zoology and Environmental Biology laboratory, University of Calabar. Photographs of the butterflies and bumblebees were taken immediately after collection and during identification with anti-blur technology super steady shot Sony cyber- shot digital camera with ISO 300 film speed, 3xs zoom and face detection ability. Number of butterflies and bumblebees collected is presented as mean values of two and four sampled areas. For the bird census, all nestling and foraging birds within 100m of each sample point during a 5 minutes time frame were counted. The birds were sampled by sighting; Care was taken to observe the appearance, habit, number of occurrence and vocal sound of each bird. Photographs were also taken where possible in all sampled areas. Identification was made using Svensson and Grant, (1999) and Perlos, (2002) methods. Flying birds were not included in the survey as they could not be said to use the agricultural land (unless birds that feed during flight). Tree species were identified, counted and recorded once on each sampled farm at the sampled points utilized for the birds, butterflies and bumblebees census. All sampled sites were visited once a day for three consecutive days from 6.30am-9.30am for the pollinator census. The mean of all observations was used in the data analysis. The SPSS (Statistical Package for the Social Sciences) version 10.0 was used for all statistical analysis.

Analysis: The Watt Market was adopted as the Central Business District (CBD) and Mile 8 was assumed to be the limit of the urban area. Thereafter, a 4 kilometere buffer zone in an Arc GIS environment was created from mile 8 to delimit the peripheries of the urban area. The delineation of sprawl adopted the format of Atu, Offiong, Eni, Eja and Esien (2012). Five areas out of the 8 identified areas that have witnessed significant sprawl development in the past decade were purposively chosen for the study. Thus, the sampled locations included Anantigha in Calabar South Local Government Area, Edim Otop/Satellite town, Parliamentary Extension, Ekorinim and Esuk- Utan in Calabar, Municipality. The study areas were further classified into Farmland Within Sprawl (FLWS) and Farmlands Outside Sprawl (FLOS) giving a total of 10 sampled sites. Two farms were then selected from each of the sites as the sampled units, thus, a total of 20 farms were sampled for the study. The multiple correlation analysis was utilized in testing the hypothesis. Birds in agricultural lands that have a frequency of 1 were classified as very rare, bird species with a total frequency of two were classified as rare, and those with frequencies of 3-10 were classified as common and frequencies of 11 and above were classified as abundant. The total number of bird species and the average of all observation for butterflies and bumblebees with the total number of tree species were used for the statistical analyses. The relationships were tested for the total number of bird species and the total number of butterfly and the total number of bumblebee's species in relation to the average size and the farm patches. The relationship between farm size, tree diversity and diversity of avian fauna (birds) on agricultural lands was tested with multiple correlation analysis. The formulas for the multiple correlation analysis adopted from (Udofia, 2006) are presented as follows

$$ryx_1 = \frac{n.\ \sum x_1 y - \sum x_1 . y}{\sqrt{n . \sum x_1{}^2 - (\sum x_1)2} . \sqrt{n .\ \sum y^2 - (\sum y)^2}}$$

$$ryx_2 = \frac{n.\sum X2y - \sum X2.y}{\sqrt{n . \sum x_2{}^2 - (\sum x_2)2} . \sqrt{n . \sum y^2 - (\sum y)^2}}$$

$$ryx_1x_2 = \frac{n.\ \sum x_1x_2 - \sum x_1 . \sum x_2}{\sqrt{n . \sum x_1{}^2 - (\sum x_2)2} . \sqrt{n . \sum x_2{}^2 - (\sum y)^2}}$$

$$r^2\ x_1x_2 = \frac{\sqrt{r^2\ yx_1 + r^2\ \ x_{2-2\,xy_1}.\ ryx_{2\,.r}\, x_1x_2}}{1 - r^2\ x_1x_2}$$

Where:

n = number of sampled farms

y= bird species on sampled farmlands

x_1= farm size

x_2 = number of tree species (diversity)

r = correlation coefficient

Findings

A total of 20species of butterflies in five families of over 280 butterflies were identified during sampling (Table 1). Pieridae family had the highest occurrence of 30 (42.85 per cent), Lycaeidae 18 (27.7 per cent) occurrence and the least occurrence was recorded in the Satyridae and Acraidae 3 (4.29 per cent). The highest species occurrence was the Zizeeria kynssna species with 17 (14 per cent) followed by Mylothris sp with 29.99 per cent, Acraea eponina 11.43 perc ent. Generally, FLOS had more butterfly diversity with 42 (62.69 per cent) than FLWS with 25 (37.31 per cent). This finding implies that species of butterflies in agricultural lands are declining while others, such as those in the Satyridae family are in danger of becoming extinct unless drastic conservation measures are adopted. The mean number of butterfly species identified per sampled area is illustrated in Table 2.

Table 1: Mean number of butterfly species identified in agricultural lands

N	Family	Genus/Species	Mean number collected	% abundance
1	Pieridae	*Leptosia medusa*	5.0	7.14
		Catopsilia florella	3.0	4.29
		Mylothris rhodope	11.0	15.7
		Mylothris chloris	10.0	14.29
		Colotis evippe	1.0	1.43
			30.0	42.85
2	Nymhalidae	*Acraea eponina*	8.0	11.43
		Précis oenone	2.0	2.86
		Hypolimnas missippus	1.0	1.43
		Hypolimnas sp	1.0	1.43
		Euriphene tadema	1.0	1.43
		Eunica amulia	2.0	2.86
		Byblia achellia	1.0	1.43
			16.0	22.87
3	Lycaenidae	*Thermoniphas micylus*	4.0	5.7
		Zezeeria knyssna	12.0	17.14
		Spindasis sp	1.0	1.43
		Spindasis mozambica	1.0	1.43
			18.0	25.7
4	Satyridae	*Ypthima doleta*	1.0	1.43
		Bicycles asoctus	1.0	1.43
		Ypthima sp	1.0	1.43
5	Acraeidae	*Bematistes vestalis*	3.0	4.29
			6.0	8.58
		GRAND TOTAL	70.0	100.0

Table 2: Mean distribution of butterfly species per sampled area

Family	Species	Edim Otop		Anantigha		Esuk Utan		Ekorinim		Parliamentary	
		FLOS	FLWS	FLOS	FLWS	FLOS	FLWS	FLOS	FLWS	FLOS	FL WS
Pieradae	*Leptosia medusa*	5	0	0	0	0	0	0	0	0	0
	Catopsilia florella	1	0	0	0	0	0	0	1	1	0
	Mylothris rhodope	0	2	0	2	2	2	0	1	1	0
	Mylothris chloris	0	0	0	0	3	4	0	3	0	0
	Colotis evippe	0	0	0	1	0	0	0	0	0	0
Nymhalidae	*Acraea eponina*	5	0	3	0	0	0	0	0	0	0
	Précis oenone	1	0	0	0	0	0	1	0	0	0
	Hypolimnas	1	0	0	0	0	0	0	0	0	0
	missippus	1	0	0	0	0	0	0	0	0	0
	Hypolimnas sp	0	0	0	0	0	0	0	1	0	0
	Euriphene tadema	0	0	1	0	0	0	0	1	0	0
	Eunica amulia	0	0	0	1	0	0	0	0	0	0
Lycaenidae	*Byblia achellia*	0	0								
	Thermoniphas	0	0	1	0	0	0	0	0	0	0
	micylus	0	0	5	0	0	1	0	0	1	0
	Zezeeria knyssna	0	0	0	0	0	0	1	4	0	0
	Zezeeria amulia	0	0	0	0	1	0	0	0	0	0
	Spindasis sp			0	0	0	0	1	0	0	0
Satyridae	*Spindasis mozambica*	1	0	0	0	0	0	0	0	0	0
		0	1	0	0	0	0	0	0	0	0
	Ypthima doleta	0	0	1	0	0	0	0	0	0	0
	Bicycles asotus										
Acraeidae	*Ypthima sp*	0	0	2	0	0	0	1	0	0	0
	Bematistes vestalis										

Only two species of bumblebees were identified on sampled farms. FLOS had one species (specifically on FLOS 3 and FLOS 4) Table 1. FLWS had two Bombus species identified on FLWS 1 and FLWS 2. Both FLOS and FLWS had 10 per cent occurrence of bumblebees. The two species of BOmbus identified during sampling are illustrated in Plate 1. Bumblebees exists primarirly in the Northern hemisphere, few lowland species of bumblebees exist (specifically in New Zealanad and Tasmania). Therefore, the occurrence of Bombus species on these farmlands implies that specific plant(s) attract the bumblebees to the farms. A common characteristic of the farms with Bombus species is the abundance of Ranvolfia vomitoria (illustrated in Plates 2a and 2b). Thus, Ranvolfia vomitoria is considered in this research as an attractant to Bombus species. A bumblebee like butterfly is a pollinator of the bee genus Bombus, in the Apidae family. There are over 250 known species and subspecies in 15 subgenera, existing primarily in the Northern Hemisphere although there are more common in New Zealand and Tasmania with few exception (there are a few tropical lowland species). Bumblebees are vital in the production of certain crops, because they do pollinate plant species that other pollinators cannot by using a technique called buzz pollination. For instance bumblebees are often placed in greenhouse tomato production because the frequency of buzzing a bumblebee makes effectively releases tomato pollen

Plate 1: ***Bombus species (*****bumblebees) in agricultural lands**

Plate 2a*: Ranvolfine volmitorie* plant (Indian snake tree)

Plate 2b*: <u>Ranvolfine volmitorie</u>* plant (Indian snake tree)

Two bird species identified and classified as very rare are Streptoppelia decipiens and Streptopelia selegalensis Plate 3. Bostrycgia hagedash and Egretta egretta had a frequency of two and were classified as rare. Other species such as Bueto bueto and Ploceus superciliosus were more common and abundant as shown by their frequency of occurrence in Table 3.

Plate 3: *Streptopelia decipiens* (African mourning dove)

Table 3: List of bird Species identified during sampling

Scientific name	Common Name	Frequency			Classification
		FLWS	FLOS	Total	
Egretta garzetta	Little egretta	1	1	2	Rare
Bostrycgia	Hadada	1	1	2	Rare
hagedash	Black kite	6	9	15	Abundant
Milvis migrans	Hooded vulture	2	3	5	Common
migrans	Common	5	5	10	Common
Necrosyrtes	buzzard	1	1	1	Rare
monachus	Helmeted	4	8	12	Common
Bueto bueto	guinea fowl	0	1	1	Very rare
Numida	Little button	0	1	1	Very rare
meleagris	quail	10	10	20	Abundant
Tunix sylvatica	African	9	10	19	Abundant
Streptopelia	mourning dove				
decipiens	Laughing dove	8	10	18	Abundant
Streptopelia	Lesser stripe	7	8	15	Abundant
selegalensis	swallow				
Hirundo	Village (Black				
cucullata	headed) weaver				
Ploceus	Compact				
cucullatus	weaver				
	Parasitic				
Ploceus	weaver				
superciliosus					
Anomalospiza					
imberbis					

The multiple correlation analysis was utilized at 0.05and 0.01 significant level to test hypothesis two. The dependent variable is the bird species, while farm size and tree species are the independent variables (Table 4.14). The mean scores for patch size, tree species and bird species in peripheral agricultural lands in Calabar were 1827.38, 2.25 and 3.35 (Table 4.15) respectively. Result of the multiple correlation analysis indicate that the relationship between patch size and bird species is positive at r = 0.283 (Table 4.16). Tree diversity has a positive relationship with bird diversity on farmlands with r= 0.342. These relationships are positive but not significant. On the other hand the relationship between patch size and the diversity of trees on farm lands was very significant at the 0.01 significant level at r= 0.844 (Table 4.16).

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$$r^2\ x_1x_2 = \frac{\sqrt{r^2\ yx_1 + r^2\ x_{2-2\ xy_1} \cdot ryx_{2\ .r}\ x_1x_2}}{1-r^2\ x_1x_2}$$

The result of the analysis indicates that the joint contribution of the two independent variables to the variance of bird species in agricultural lands is positive with multiple correlation coefficient value of r = 0.50. This r value is significant, implying that there is a significant relationship between farm size, tree diversity and the diversity of avian fauna in agricultural lands.

The coefficient of multiple determination r= 0.25 implies that only about 25 per cent of the variation of birds on farmlands is as a result of the sizes of the farms and the number and species of crops cultivated. The explained variation when 25 per cent is taken from 100 per cent may be attributed to other factors such as proximity of farms to natural forest, distance of farms to built -up areas, abundance of butterflies and other insects that the birds feed on and the maturity stage of the cultivated crops.

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Table 4: Results of multiple correlation of farm patch size, tree diversity and the diversity of birds in agricultural land

		Farm size	TS	BS
FS	Correlation	1	.844**	.283
	Sig. (2-tailed)		.000	.227
	N	20	20	20
TS	Correlation	.844**	1	.342
	Sig. (2-tailed)	.000		.140
	N	20	20	20
BS	Correlation	.282	.342	1
	Sig. (2-tailed)	.227	.140	
	N	20	20	20

The multiple correlation analysis was also used to examine the relationship amongst farm size, farm density and selected species in peripheral agricultural lands such as birds, butterflies and bumblebees. Result of the analysis shows that significant relationship exist among the variables. The relationship between farmsize and farm density was significant at 0.01 level Table 5. A positive and significant relationship also exist between farm size and butterfly species at r=0.553. The relationship between farm size and bird species was positive but not significant at r=0.283. Generally, there was a positive relationship amongst all inventoried variables. Farms with high butterfly diversity had high crop and *Bombus* diversity.

TABLE 5: Results of multiple correlation of patch size and patch density with birds, butterflies and bumblebees species in agricultural lands.

		Farm size	Farm density	BS	BFS	BBS
patch size	Correlation	1	.704**	.283	.551*	-.174
	Sig. (2-tailed)		.001	.227	.012	.463
	N	20	20	20	20	20
patch density	Correlation	.704**	1	.005	.353	-.239
	Sig. (2-tailed)	.001		.982	.127	.306
	N	20	20	20	20	20
BS	Correlation	.283	.005	1	.441	.549*
	Sig. (2-tailed)	.227	.982		.051	.012
	N	20	20	20	20	20
BFS	Correlation	.551*	.353	.441	1	.124
	Sig. (2-tailed)	.012	.127	.051		.603
	N	20	20	20	20	20
BBS	Correlation	-.174	-.239	.549*	.124	
	Sig. (2-tailed)	.463	.306	.012	.603	1
	N	20	20	20	20	20

*. Correlation is significant at the 0.05 level (2-tailed)
**. Correlation is significant at the 0.01 level (2- tailed)

Conclusion

The research demonstrates that sprawl has impacted negatively on biodiversity (birds and butterflies) in agricultural lands and some species of butterfly such as those in the Satyridae family are already in danger of becoming locally extinct, while Streptopelia decipien (African mourning dove) is on the verge of extinction in the locality. Atu, et. al (2012) in their study on "the effects of urban sprawl on biodiversity in peripheral agricultural lands in Calabar, Nigeria" argued that the expansion of sprawl into peripheral agricultural lands reduce the spatial extent of farmlands and fragment them leading to reduce farm sizes and adaptations to urban expansion leads to new forms of farm practices vis a vis crop types and farm management practices. Therefore, the declining status of biodiversity on peripheral agricultural lands is attributed to changes in prior crop types and farm management as a result of farmland loss due to sprawl. This is because fauna species on farmland have adapted to prior regimes of farm practices, therefore, changes in these prior farming systems as a result of sprawl development impact negatively on biodiversity as indicated by this research.
We therefore, suggest the adoption of eco- friendly farming systems such as planting of specific species of plants that attracts birds, butterflies and bumblebees (e.g. Ranvolfia volmitoria) on agricultural lands.

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