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Sprawl And Biodiversity In Cross River State, Nigeria

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Abstract

The paper sought to determine the influence of sprawl on crop types and the diversity of birds, butterflies and bumblebees in agricultural lands. The research compared the number and species of crops cultivated, birds, butterflies and bumblebees diversity between 10 peripheral agricultural lands in sprawl areas and 10 peripheral agricultural lands outside sprawl areas. At each of the farms, five sampled points were used and the mean of all observations were used for the analysis. Canonical correlation analysis was used to determine the factors influencing the diversity of birds, butterflies and bumblebees on farmlands. While the difference in crop diversity between and within species was determined by Shannon Weiner diversity index. Butterflies, bumblebees and birds were significantly correlated with the crop diversity of farm lands. Also a positive relationship was observed amongst all inventoried variables. Farms with high crop diversity had high butterfly and bird diversity. The study has implication for the sustainability of biodiversity in urban places.

Key words: Sprawl, biodiversity, peripheral lands, Cross River State

1. Introduction

One of the most challenging threats to biodiversity in the world in the 21st century is sprawl. Sprawl has been variously defined, but a central component of its definition by most authors is the physical expansion of urban areas. The Sierra Club (2001) for example, described sprawl as “irresponsible, often poorly planned development that destroys green space, increases traffic and air pollution, crowds’ schools and drive up taxes”. Deshpande (1992) compared sprawl to ‘floating water’ which occupies everywhere available for its spread. Others compare sprawl to a disease process calling it a cancerous growth or a virus, DiL’orenzo (2000). While less strident description include “the scattering of urban settlement over the rural landscape” Harvey and Clark (1971), “low density urbanization” Pendall (1999), “discontinuous development” Weitz and Moore (1998) and “the physical pattern of low density expansion of large urban areas under market conditions mainly into the surrounding agricultural areas” (European Environmental Agency, EEA2006).

Sprawl is thus the spreading out of a city and its suburbs over more and more rural land at the peripheries of urban areas. This sprawling development involves the conversion of open space, wetland, semi natural and natural vegetation and cropland into built up developed land over time. Historically, the development of sprawl has been driven by increasing urban population, increasing incomes, subsidization of infrastructural investment like roads, and physical constraints on development. Unfortunately, the consequence of sprawl on the peripheries (the dominant pattern) has been the loss and fragmentation of agricultural land which invariably culminates in the loss of biodiversity. This is because, sprawl consists of three basic spatial characteristics: low density continuous sprawl, ribbon sprawl and leapfrog development sprawl, Harvey and Clark (1971). The low density continuous sprawl is the highly consumptive use of land for urban purpose along the margin of existing metropolitan areas. This type of sprawl is supported by piece meal extension of basic urban infrastructure such as water, sewer, and roads. This extension of infrastructure leads to habitat loss through the annexation and degradation of peripheral agricultural lands. Ribbon sprawl on the other hand is urban land use development that follows major transportation arteries outwards from urban centres. In this instance lands adjacent to corridors are developed but those without direct access remain in rural land cover or uses. Over time these nearby rural land are converted to urban uses as the value of land increases and infrastructure is extended from the major road and lines. Leap frog development sprawl is a discontinuous pattern of urbanization, with patches of developed lands that are widely separated from each other and from the boundaries, although blurred in some cases by regional urban areas. Leap frog development sprawl leads to fragmentation of habitats. Sprawl fragments agricultural habitats when roads are built on existing agricultural lands.

Therefore, for farmers to compete with these advancing alternative uses, they must work remaining agricultural lands more intensively, farm on marginal land, change to more profitable crops or shift to operation that require less investment. These changes in prior pattern of land use invariably affect the species that have adapted to these areas. Hence, changes in agricultural lands are of concern in that they affect the overall level biodiversity, including the population of widespread and common species as well as threatening rarer species.

This is because species diversity is not restricted to pristine habitats. Agricultural lands in and around cities are also home to many imperiled species. These areas therefore, have potential for species restoration as long as they are protected from development.

Hence, activities in the peripheries have the potential to enhance or degrade the quality of the surrounding land. Additionally, many of the geographical changes taking place at the periphery are associated with the transfer of land from rural to urban uses, which is a much more fundamental alteration than many land use changes which take place in the urban areas. This is because changes in the peripheries although less concentrated is inherently important because larger area is involved and thus more biodiversity are likely to be affected. Regrettably, agricultural lands and biodiversity are considered to be mutually exclusive, hence, the literature on sprawl and biodiversity in peripheral agricultural land is limited to studies on the effects of urbanization on the environment such as those by (Kolankiewicz and Beck, 2002) and on agricultural land by (Lopez' Thomlinson, and Mitchell 2001; Atu, Offiong, Eni, Eja and Esien 2012), biodiversity (bird) by (Henning and Edge 2008; Atu, Offiong and Eja 2013). In spite of this studies, the relationship between sprawl cropping patterns, crop types and selected species of fauna and flora diversity in agricultural land has not been investigated. This paper is thus, an attempt to bridge the gap in the literature. We therefore, asked: Is there a difference in agro and faunal diversity of agricultural lands impacted by sprawl from those unaffected? Is there a difference in agro and faunal diversity in agricultural lands among the different sprawl formations? Is there a difference in the diversity of species (birds, butterfly and bumblebees) within agricultural lands impacted by sprawl from those unaffected? And does the ratio of crop diversity to faunal species (birds, butterflies and bumblebees) vary between lands affected by sprawl from those unaffected? And hypothesized that: Farm size and crop diversity have no significant relationship with the diversity of birds, butterflies and bumblebees in agricultural lands; and that there is no significant difference in the diversity of butterflies, birds and bumblebees' between peripheral agricultural lands impacted by sprawl and peripheral agricultural land un-impacted.

1.1 Objectives

The objective of the study is to examine the relationship between sprawl and biodiversity in in Calabar, Nigeria. The specific objectives of the study are:

1. To compare crop types (diversity) and faunal diversity on farmlands within sprawl areas and farmlands outside sprawl areas.
2. To examine the differences in crop diversity (between and within species) among the different sprawl types.

2. Literature

Many may believe that sprawl is a recent phenomenon, but, sprawl in fact, has been around for quite some time. One of the earliest users of the word sprawl in terms of land use was Draper, (1939) who stated that, 'perhaps diffusion is to kind a word… in busting its bounds, the city actually sprawled and made the countryside ugly… uneconomic (in terms of) services and doubtful social value'. Since then, the problem of urban sprawl has received much attention from researchers and findings from such researches conclude that the sprawl of a city leaves marked impact on the land use pattern and biodiversity of the affected area as evidence in the following literature.

Herkert, J. R., D. L. Reinking, D. A. Wiedenfeld, M. Winter, J. L. Zimmerman, W. E. Jensen, E. J. Finck, R. R. Koford, D. H. Wolfe, S. K. Sherrod, M. A. Jenkins, J. Faaborg and S. K. Robinson (2003) attributed the decline of grassland birds to loss and fragmentation of grasslands in North America. To assess the effect of fragmentation on the reproductive success of grassland bird, they researched on 'effects of praire fragmentation on the nest success of breeding birds in the Midcontinental United States'. The rates of nest predation and brood parasitism were measured for four species of birds (Grasshopper sparrow/*Ammodramus savannaru*, Henslow's sparrow/ *Ammodramus henslowii*, Eastern meadowlark/ *Sturnella magna*, and Dickcissel/ *Spiza Americana*) in 39 prairie fragments ranging from 24 to greater than 40,000 hectares in five states in the Midcontinental United States. The results show that nest predation rates were significantly influenced by habitat fragmentation. The difference in nest predation rates between large fragments (54-68 per cent of all nest lost to predators) and small fragments (78-84 per cent lost to predators) suggest that fragmentation of prairie habitat may be contributing to regional declines of grassland birds. Maintaining grassland birds therefore, requires protection and restoration of large prairie areas.

In a similar study, (Veech, 2006) did a 'comparison of landscapes occupied by increasing and decreasing populations of grassland birds in the Midwest and Great Plains of the United States'. He opined that grassland bird species and abundance have declined in the region due possibly to loss of natural grasslands occasioned by urbanization. The study used a 20 year data from the North American Breeding Bird Survey to identify increasing, decreasing and stable populations of 36 nesting grassland birds. The proportions of nine different land cover types (restored grassland, rangeland, cultivated cropland, pasture, non-cultivated cropland, forest, urban land and water) were calculated. Increasing population were found in landscapes that contained significantly more restored grassland and ranged land but significantly less forest land and urban land than landscapes inhabited by decreasing populations. The results suggest that grassland birds would benefit from government intervention. Lepczyk, C.A., C. H. Flather, V. C. Radeloff, A. M. Pidgeon, R. B. Hammer and J. Liu (2008) hypothesized that patterns of association between humans and biodiversity typically show positive, negative or negative quadratic relationship which can be described by three hypotheses: biologically rich areas that support high human population densities occurs with areas of high biodiversity (productivity); biodiversity decreases monotonically with increasing human activities (ecosystem stress); and biodiversity peaks at intermediate levels of human influence (intermediate disturbance). Their hypotheses were tested in a study on ‘human impacts on regional avian diversity and abundance’ where anthropogenic land cover and housing units were compared as indices of human influence, with bird species richness and abundance across the Midwestern United States. Richness of native bird species were modeled with candidate models of land cover and housing to evaluate the empirical evidence. Native avian richness was highest where anthropogenic land cover was lowest and housing units were intermediate based on model averaged predictions among a confidence set of candidate models. Also there was great variability in housing units across the land cover gradient that indicates that an intermediate disturbance relationship is supported. This finding suggests that preemptive conservation action should be taken where areas with little anthropogenic land cover such as agricultural lands should be given conservation priority.

Looking at the effects of climate and land- use change on species abundance in a Central European bird community, (Lemoine, N., H. Gunther, M. Peintinger and K. Bohning-Gaese 2007) agree that changes in land – use and climate have an impact on ecological communities. Their study examined the ‘influence of land- use and climate alteration on changes in the abundance of Central European birds’. The impact of land- use and climate change were examined by contrasting abundance changes of birds of different breeding habitat, latitudinal distribution, and migratory behavior using semi-qualitative breeding bird atlas of Lake Constance which borders Germany, Switzerland and Austria. Changes in the regional abundance of the 159 coexisting bird species from 1980-1981 to 2000-2002 were influenced by all three factors. Farmland birds, species with northerly ranges and long distance migrants declined and wetland birds and species with southerly ranges increased in abundance. Sekercioglu, C. H., S. R. Loarie, F. O. Brenes, P. R. Ehrlich and G. C. Daily (2007) believe that understanding the persistence mechanism of tropical forest species in human dominated landscapes is a fundamental challenge of tropical ecology and conservation. Many species, (including more than half of Costa Rica’s native land birds) according to the findings of their study ‘on the persistence of forest birds in Costa Rican agricultural countryside’ use mostly deforested agricultural countryside. They asserted that the species of birds in their study did not commute from extensive forest but rather; they fed and bred in the agricultural countryside. Though, they conceded that specific species such as *icterocephala* and *T. assimilis* which are more habitat sensitive species were highly dependent on the remaining trees. These findings indicate that agricultural lands have high potential for conservation value which can be enhanced with modest integration of tree cultivation on farms. The importance of tree cultivation to specific species was also demonstrated by the findings of a research carried out by (Solis- Montero, L., A. Flores-Palacios and A. Cruz-Angon 2005) on ‘shade coffee plantations as refuges for tropical wild Orchids in Central Veracruz, Mexico’. The findings indicate that three Orchid species had high population densities (greater than 800plants/ha). Furthermore, coffee plantation had abundant Orchid populations with log- normal size/ age structures. It is thus believed that pollinators that allow orchids to set a high proportion of fruits persist in shade coffee plantations.

In evaluating the importance of human modified lands for Neotropical bird conservation, (Petit and Petit 2003) examined bird communities associated with 11 natural and human modified habitats in Panama and assessed the importance of those habitats for species of different vulnerability to disturbance. They calculated habitat importance scores using both habitat preferences and vulnerability scores for all species present. Species of moderate and high vulnerability were categorized as forest specialist or forest generalist. The findings show that, even species rich non- forest habitats provided little conservation value for the most vulnerable species, though; shaded coffee plantations and gallery forest corridors were modified habitats with relatively high conservation value.

The effects of urban sprawl on birds at multiple levels of biological organization’ were studied by Blair (2004). Blair explored the effects of sprawl on native bird communities by comparing the occurrence of birds along gradients of urban land use in southwestern Ohio and northern California and by examining patterns at the individual, species, community, landscape, and continental levels. His findings confirm that at the species level, sprawl affected local patterns of extinction and invasion; the density of different species peaked at different levels of urbanization and at the community level species richness and diversity peaked at moderate levels of diversity. While the result from the continental level indicates that local extinction of endemic species followed by the invasion of weedy species leads to the functional homogenization between eco-regions. Devictor V., R. Julliard, D. Couvet, A. Lee and F. Jiguet (2007) tried to determine the 'Functional Homogenization Effect of Urbanization (sprawl) on Bird Communities' by studying the community richness and dynamics of birds in landscapes recently affected by urbanization. They found that sprawl induces community homogenization and populations of specialist species become unstable with sprawl. The result emphasized that urbanization has a spatial impact on the spatial component of communities and also highlights the debilitating effect of sprawl on communities over time. This result shows that sprawl is a strong driving force in the homogenization of biological community with dire consequences on biodiversity. In similar studies, Bakker, K. K., D. E. Naugle and K. F. Higgins (2002) evaluated the influence of local and landscape attribute on the occurrence and density of seven Passerine species in grasslands throughout South Dakota. Landscape composition and land cover were quantified at three spatial scales: 400, 800 and 1600 metres radii from the transect centre. Separate habitat modules were also generated for mixed grass and tall grass prairie regions to depict the way birds respond to geographic variation in local and landscape structure. Their findings indicate that occupancy rates for passerine species were higher in small patches within landscapes with high grassland abundance than in large patches within low grassland landscapes.

Ricketts, T. H., G. C. Daily, P. R. Ehrlich and J. P. Fay (2001) asserted that different agricultural production systems may offer similar habitat elements and thus may not substantially differ in their capacity to support native moth population and that the majority of moths utilize native and agricultural lands, thus forming relatively high species richness and abundance around forest fragments. This assertion was based on the findings of their study titled 'Countryside biogeography of moths in a fragmented landscape: biodiversity in native and agricultural habitat', where they sampled moth species richness or abundance within 227 hectares forest fragments and four surrounding agricultural land in the Las Cruces area of Costa Rica. They found that agricultural lands within 1 kilometer of the forest fragments had significantly higher richness and abundance than those farther than 3.5 kilometres from the fragments. Additionally, species composition differed significantly between distance classes but not among agricultural land.

These findings significantly differed from those of (Winfree, R., T. Griswold and C. Kremens, 2007) who tried to understand how well species persist in human dominated ecosystems because anthropogenic habitats may offer more opportunities for conservation since protected areas constitute a small fragment of the Earth's surface. They investigated how pollinator (bees: *Hymenoptera apiformes*) are affected by human land use at the landscape and local scales in New Jersey. They established forty sites that differed in surrounding landscape cover or local habitat and collected 2551 bees of 130 species. The natural habitat in this ecosystem is a forested ericaceous heath. Their findings show that bee abundance and species richness within forest habitat decreased with increasing forest cover in the surrounding landscape. Similarly, bee abundance was greater in agricultural fields, suburban and urban development than in extensive forest, and the same trend was found for species richness. Their findings suggest that moderate anthropogenic land use such as crop cultivation is compatible with pollinator species whereas some bird species may need the presence of remnant nearby forest to exist in landscapes dominated by humans. This remnant forest can be provided by farming practices such as agro forestry practice.

Effects of sprawl on resident fauna have been most extensively studied in logged and fragmented landscapes; but the condition of sprawl as they relate to crop types and area sensitive species response in agricultural lands has received relatively little attention. Fragmentation arising from sprawl significantly differs from the clearing associated with agricultural practices, because house and pavements are relatively permanent in comparison with the reduction of species associated with farming landscapes. It is to fill the gap in literature that this research intends to look at the relationship between urban sprawl and birds, butterflies and bumblebees in agricultural lands.

2.1 Study Area

Calabar is located between longitudes 8^o 17' 00'' and 8^o 20' 00'' E and latitudes 4^o 50' 00'' and 5^o10' 00''N at the Southern part of Cross River State. It is the administrative headquarters of Cross River state, Nigeria. Calabar Metropolis comprising of Calabar Municipality and Calabar South Local Government Area covers an area of approximately1480sqkms. Calabar, is sandwiched between the Great Kwa River to the East and the

Calabar River to the West Fig.1. The city is located on the Eastern bank of the Calabar River. Sprawl expansion to the south is hindered by the Mangrove swamp, thus the area currently experiencing rapid sprawl development is Eastward up to the Great Kwa River, Westward towards the Calabar River and Northward. Calabar has recently been designated as the tourism hotspot of West Africa, as such the city has witnessed unprecedented influx of people from the rural areas in search of better opportunities and tourists from other part of Nigeria and the world. This has necessitated the building of service structures such as hotels, transportation lines, commercial, industrial and residential areas. These new developments are occurring on prior peripheral agricultural land as is observed in areas like Edimo- Otop and Ekorinim. The developments in these areas are the low density continuous development that is highly consumptive of land. At the parliamentary axis new roads have been created and existing road network expanded to accommodate the increased traffic and this has contributed to the development of ribbon sprawl at Parliamentary Road Extension. Leap frog development sprawl is found in parts of Ekorinim, parts of Parliamentary village Edimo-Otop and Anantigha. All these areas were former peripheral agricultural lands that have been annexed to form one continuous block of urban land uses with fragment of agricultural land in between some areas. With this rapid transformation of the peripheries of Calabar taking place in the last decade the urban periphery of Calabar has become key focal area of research because this zone is a marginal area with considerable influence on the surrounding land and biodiversity.

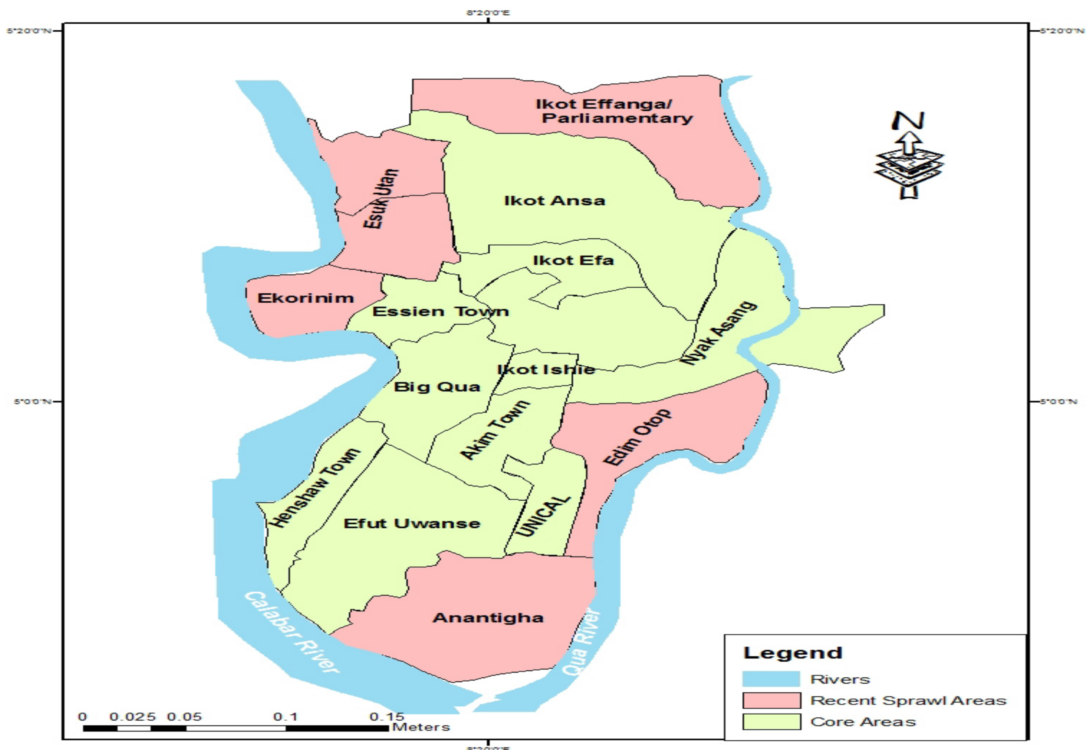

Fig 1 Calabar showing areas of core and recent sprawl development

3. Methodology

The types of data acquired for the study include: data on the spatial extent of peripheral agricultural lands in sprawl areas (PALISA) and peripheral agricultural lands outside sprawl areas (PALOSA), proximity of farm lands to built- up areas. The total number and types of cultivated crops and tree species on PALISA and PALOSA were collected. Inventories of the diversity of butterfly, birds and bumblebees were also collected for the study. Field observation, measurement and counting by the researchers was the primary data source for birds, butterflies and bumblebees inventory, number 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 2010.

3.1 Sampling

Sampling was carried out from identified farms from May 20th - August 20th 2012 (which is the peak of the farming season). The study adopted the format of Atu, Offiong, Eja, Eni and Esien (2012) in the demarcation of the urban peripheries. Five sprawl areas that were used for the study are: Ekorinim, Esuk Utan, Edim- Otop, Anantigha and Old Parliamentary village sprawl areas (see Fig 1). Data were collected from 10 sampled sites (5 within sprawl areas and 5 outside sprawl areas). At each of the sampled sites two farms were purposively chosen. Thus, inventories of birds, butterflies, bumblebees, cultivated tree and food crops were collected from 20 sampled farms or plots. At each of these twenty farm plots, samples were taken at five points (10metres apart) on each of the sampled farms, including the farm centre and its immediate surroundings, giving a total of 100 sampled points. 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 first 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. The butterflies and bumblebees census was done by the researcher with the assistance of a zoologist and two assistants. Number of butterflies and bumblebees collected is presented as mean values of two and four sampled areas.

The bird census utilized the format of Atu, Offiong and Eja (2013), 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; the appearance, habit, number of occurrence and vocal sound of each bird were observed and recorded. 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).

Crop types and tree species were identified, counted and recorded once on each sampled farm 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.

3.2 Analysis

The inventories of crop types on PALISA and PALOSA were compared to examine the differences in the types of crops cultivated on the two farm areas. Canonical correlation and paired samples statistical techniques were employed for the analysis. The total number of bird species and the average of all observation for butterflies and bumblebees with the total number of crops and 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 of the farm sizes and crop diversity (total number of crop species on farmlands) as utilized by Belfrage, K., Bjorklund, J. and Salomonsson, L. (2005).

The difference in crop diversity between and within species among the sprawl formations was examined with the use of Shannon Weiner Diversity index given as:

$$D = -\sum_{i=1}^{s} pi \ (logiPi)$$

Where:

D = the value of Shannon Weiner Diversity index

P_i = the proportion of the ith species log i = the natural loga

S = the number of species on the farms

To examine the relationships amongst farm size, crop types and the diversity of birds, butterflies and bumblebees in agricultural land. Canonical correlation analysis was used to determine the factors influencing the diversity of birds, butterflies and bumblebees on farmlands. Canonical correlation is one of the general forms of the multivariate techniques (Nie, N. H., C. H. Hull, J. G. Jenkins, K. Stenbrenner and D. H. Bent 1970) which sort to find the linear association between one set of variables, the predictor variables $x_{1,}$ $x_{2,}$ $x_3 \ldots x_n$ and another set of variables, the criterion variables y_1, y_2, $y_3 \ldots y_n$. In canonical correlation, one has two or more x and two or more y variables. It is this characteristic of the canonical correlation that makes it a suitable choice for the analysis of the effects of farm size and crop diversity on butterflies, bumblebees and birds' diversity in agricultural lands. The variables consist of the Y and X variables. The Y variables are the dependent variables and the X variables are the independent variables. The Y and X variables are shown below:

Y_1 = Bumblebees species (BBS)

Y_2 = Bird species (BS)

Y_3 = Butterfly species (BFS)

X_1 = Farm size (M)

X_2 = Crop Diversity (CD)

Therefore, the canonical variate representing the optimal linear combination of the criterion (dependent) and predictor (independent) variables and the canonical correlation can be presented as:

W_m= am_1 x_1+ am_2 x_2+ am_p x_p…(3.1)

V_m= bm_1 x_1+ bm_2 x_2+ b m_p x_p…(3.2)

The correlation between Wm and Vm is the canonical correlation (CM). The correlation coefficient is estimated as (am_1, am_2, ….am_p and bm_1, bm_2,……..b m_p). A serial process that explains the maximization technique is given as follows: let the first group of p variables be represented by the random vector, X ($px_{1)}$), and let the second group of q variables be represented by the random vector, Y ($qx_{1)}$). For random vector X and Y, population mean and (co) variables would be as follows:

E(X) = N ; Cov (X) = $\sum_{11}$ . . . (3.3)

E(Y) = N ; Cov (Y) = $\sum_{22}$ . . . (3.4)

.`. Cov (X, Y) = $\sum_{12}$ = $\sum_{21}$ . . . (3.5), SAS (1988).

Furthermore, X and Y random vectors and (Co) variance matrices can be written as follows:

$$\begin{bmatrix} X_{px1} \\ Y_{qx1} \end{bmatrix} = \begin{bmatrix} X_1 \\ x_2 \\ \vdots \\ x_p \\ y_1 \\ y_2 \\ \vdots \\ y_q \end{bmatrix} \quad \Sigma = \begin{bmatrix} \Sigma_{11_{pxp}} & \Sigma_{12_{pxq}} \\ \Sigma_{21_{qxp}} & \Sigma_{22_{qxq}} \end{bmatrix} \ldots (3.6)$$

So that the linear combination of the components of X and the component of Y would be W = $a^i x$ and V = $b^i y$, respectively. Then W and V have the expectation of zero and (Co) variances:

Var (W) =a^1 Cov(X) a=$a^1 \sum_{11}{}^{a}$ … (3.7)

Var (V) = b^1 Cov(Y) b= b^1 $\sum_{22}{}^{b}$… (3.8)

Cov (W, V) = a^1 Cov(X, Y) b = $a^1\sum_{12}{}^{b}$ … (3.9)

Consequently, the correlation coefficient between W and V is:

$$C = \frac{a^1\Sigma_{12}b}{\left[(a^1\Sigma_{11}a)(b^1\Sigma_{22}b)\right]^{1/2}} \ldots (3.10)$$

The statistical significance of Wilk's Lambda Λ requires the estimation of the following statistics:

$$x^2 = -[N - 0.5(p + q + 1)]\iota_n\Lambda \ldots (3.11)$$

Where:

N = number of cases

ι_n= denotes the natural logarithm function;

P = number of variables in one set and

q = number of variables in the other set.

Following from (Sharma, 1996), the redundancy measure for each CanCorr calculated to determine how much of the variance in one set of variables is accounted for by the other set of variables. Consequently, redundancy measure was formulated as indicated in equation 3.12 and 3.13.

$$\Omega M_{V1W1} = \text{AV } (y/v_1) * C_{2^1}^2 \ldots (3.12)$$

$$\text{AV}(\text{Y}/V_{2^1} = \frac{\sum_{j=1}^{q} \pounds Y_{jj}^2}{q} \ldots (3.13)$$

Where:

AV(Y/$V_{2'}$) = Average vacancies in Y variables that is accounted for

L $Y^2{}_{ij}$ =loading of the j^{th} Y variable on the i^{th} canonical variate

q = number of inventoried pollinator species

$C_{2'}^2$ = shared variance between V_1 and W_1

The paired sample 't' test was used to determine the difference in patch sizes, patch density and crop diversity of farmlands impacted by sprawl from farmlands un-impacted by sprawl. The paired t- test is a statistical technique used to compare two sample distributions (Nie, et. al.1970). Here the two samples are farmlands within sprawl (X_1) and farmlands outside sprawl (X_2). The purpose of pairing is to reduce extraneous influences on the variable being measured. That is pairing reduces the effect of subject to subject variability. To compute t for paired samples, the paired difference variable D = X_1-X_2 is formed where X_1before treatment and X_2 the measurement after. D is normally distributed with mean δ. The sample mean and variance ($\bar{d}$ and$\dot{S}\bar{a}$) are computed, then:

$$t = \frac{\bar{d} - \delta}{s_{\bar{d}}}$$

$\bar{d}$ = n-1(where n is the number of pairs), and

$$s_{\bar{d}} = \sqrt{(S_1{}^2 + S_2{}^2) - \frac{2\sum X1X2}{n-1}} / n$$

($\sum X_1X_2$)(n-1) is the covariance between X_1 and X_2 (Nie, et. al. 1970). Since the covariance is proportional to the correlation between coefficients, this is sometimes called a correlated t.

4. Findings/discussions

The most significant difference between PALISA and PALOSA was in the number and variety of crops cultivated per farmland between the two farm areas. The minimum number of crops cultivated on PALOSA was

2 and maximum species variety was 7, while PALISA had 3 as the minimum and 13 as the maximum variety of crops. It can be concluded from this observation that the farms within the sprawl areas are more diverse in terms of crop species but a close look at Table 1 indicate that PALISA farms concentrate mainly on cereal, veggies and spices with little mixture of root crop cultivation (this is attributed to the uncertainty in land holding which has compelled farmers to shift their crop cultivation to mostly vegetables and spices that have short maturation period and immediate market and the fact that farming may not compete favourably with urban uses in the long run as farmlands within sprawl areas are at the 'margin of transference' because of higher rent return on alternative uses). On the other hand, PALOSA had more of tubers, and cereal. Difference was also noted in the method of cultivation between PALOSA and PALISA. In monocrop farming systems, PALISA cultivate vegetables, for instance *Talinum triangulare* in small plots of an average size of 111.88m^2 and PALOSA cultivate root crops such as *Manihot esculenta* in large single blocks of average size 3605.8m^2. The integration of tree crops on farmlands were observed only on PALOS, Plates 1a and 1b.

Plate 1a: Monocrop farm of *Talinum triangulare* at PALISA Anantigha.

Plate 1b: Monocrop farm of *Manihot esculenta* at PALOSA Anantigha.

Table 1: Crop/tree diversity on PALISA and PALOSA.

Common Name	Scientific Name	PALISA % cultivation	PALOSA %cultivation
Vegetables			
Waterleaf	*Talinum triangulare*	90	40
Fluted pumpkin	*Telfaria spp*	80	30
Okro	*Abelmoschus esculentus*	30	00
Melon	*Curcubicea spp*	40	00
Cucumber	*Cucumis sativus*	20	00
Maize	*Zea mays*	60	40
Green	*Amaranthus cordatus*	30	00
Tomatoes	*Lycopersicum esculantum*	30	00
Bitterleaf	*Vernonia amygdalina*	30	00
Garden egg	*Solanum melongena*	40	00
Spices			
Scentleaf	*Ocimum gratissimum*	70	00
Curry	*Murraya koeniyi*	40	00
Pepper	*Capsicum maximum*	50	10
Tubers			
Cassava	*Manihot esculenta*	10	70
Wateryam	*Dioscorea alata*	00	40
Yam	*Dioscorea spp*	10	10
Sweet yam	*Dioscorea rotundata*	10	70
Groundnut	*Arachis hypogaea*	10	00
Tree crops			
Banana	*Musa sepentum*	10	00
Plantain	*Musa spp*	00	10
Pawpaw	*Carica papaya*	10	10
Sugar cane	*Saccharum officinarum*	00	00
Oil palm	*Elaeis guinensis*	00	30
Peach	*Nauclea latifolia*	00	10
Sand paper tree	*Streblus asper Lour*	00	20
Hog plum	*Spondias mombis*	00	10
African rubber	*Hevea spp*	00	30
Mango	*Mangifera indica*	20	10
Indian snake tree	*Ranvolfia vomitoria*	40	20
Black pear	*Euphorbia trigona*	00	40
Milk tree	*Dacryodes edulis*	00	10
Raffia palm	*Raphia farinifera*	00	40
Orange tree	*Citrus sinensis*	00	20
Guava	*Psidium guajava*	00	10
Avocado pear	*Persea Americana*	00	40
Neem	*Azadirachta indica*	10	00
Indian bamboo	*Bambusa tulda*	00	20

Findings from the canonical analysis indicate that the canonical correlations between the pairs of independent variables (farm size and crop diversity) with the dependent variables (butterflies, bumblebees and birds' species) were 0.50, 0.50, 0.65, 0.55, 0.97 and 0.87. These results imply that there is a positive relationship between the sets of dependent and independent variables. The relationship between the first sets of variables (farm size, crop diversity and butterfly species was the highest) 0.996 and 0.871 and their corresponding probabilities of significance were 0.00 and 0.073 (P≤ 0.01) Table 2a. In other words, the canonical correlations between the first and second pair were found to be significant at 1 per cent level of probability ((P≤ 0.01) from the likelihood ratio test. The estimated canonical correlation was the highest (0.996) for the pair of canonical variates (V_{1} and W_{1}) albeit comparatively small (0.871) for the second pair of variates (V_2 and W_2). From the first pair of canonical variates, it is implied that bumblebees' species (BBS), Bird species (BS) and butterfly species (BFS) are highly significantly correlated with farm size and crop diversity. Significance of Wilks' Lambda further confirms this test. Since the canonical correlations between the first and second pair of canonical Variables were found to be significant, then the two pairs of canonical variates were considered. The redundancy measure of 0.92 Table 2b implies that 28 percent of the variance in the Y variables is accounted for by the X variables.

Table 2a: Summary result of canonical correlation analysis relating BBS, BS & BFS with CD and M in agricultural land

Variable	Function 1				Function 2			
	W	L	L^2	$\%\sum L^2$	W	L	L^2	$\%\sum L^2$
Dependant set								
BBS	1.597	-0.174	0.030	0.038	0.126	-0.015	0.00025	0.00328
BS	1.162	-0.422	0.174	0.227	1.257	-0.225	0.051	0.669
BFS	27.917	-0.758	0.578	0.734	3.421	0.158	0.025	0.328
Independent Set								
M (BBS) CD	0.938 0.980	0.937 0.993	0.878 0.986	0.470 0.530	0.922 0.998	0.921 0.974	0.848 0.949	0.472 0.528
Diagnostics								
Canonical R Canonical root	0.996 0.992				0.871 0.759			
Chi-square(x^2)	76.558				17.084			
Degree of freedom	22				10			
Level of significance	0.00				0.073			

W= Canonical weight; L columns= Canonical loadings; $\sum L^2$ = the result derived from summing the L^2 for the dependent and independent variable sets separately and expressing each variable as a percentage of the total for its respective variate

Table 2b: Redundancy index for canonical functions

Canonical function	Root	Variance extracted	Redundancy	Proportion of total redundancy
Dependent set:	R^2			
1	0.992	0.261	0.26	0.93
2	0.759	0.025	0.02	0.07
Independent set:				
1	0.992	0.932	0.92	0.58
2	0.759	0.899	0.68	0.42

The result of the student t-test analysis is presented in Table 3. Pair one 1 compared the species of butterflies in PALISA with those of PALOSA. The result revealed that significant difference exists between the species of butterflies in PALISA and PALOSA. This is because the calculated t- value of 2.792 at 5 per cent level of significance when the degree of freedom (df) = 9 is greater than the critical t- value of 2.262. This implies that significant difference exists between species of butterflies in PALOSA and PALISA. Pair 2 of the analysis compared the means of bird species in PALISA with those of PALOSA. The calculated t- value of 1.447 was less than the critical t value of 2.262 at 5 per cent level of significance when degree of freedom (df)=9, implying that no significant difference exists between the bird species of PALISA and PALOSA. Pair 3 compared the species of bumblebees between the PALOSA and the PALISA farms. The calculated t- value 0f 0.802 is less than the critical t-value 2.262 at 5 percent level of significance when DF=9. This result demonstrates that no significant difference exists between the species of bumblebees in PALOSA and PALISA farms.

Table 3: Result of paired samples comparison of butterflies, birds and bumblebees in PALISA and PALOSA

	Paired Differences					t cal	Df	t tab	P
	Mean	Std. Deviation	Std Error Mean	95%Confidence Interval of the Difference					
				Lower	Upper				
Pair 1 BFS	+2.10000	2.37814	.75203	-3.80122	-.39878	+2.792	9	2.262	5
Pair 2 BS	+2.50000	5.46199	1.72723	-6.40727	1.40727	+1.447	9	2.262	n5
Pair 3 BBS	.20000	.78881	.24944	-.36428	.76428	.802	9	2.626	n5

The result of the analysis of crop diversity and sprawl formation presented in Table 4 shows that the leap frog development sprawl was the most diverse of the sprawl formation with a diversity index of D=3.2. Continuous development sprawl was the least diverse of the sprawl formations in terms of crop species with a diversity index of D = 0.25. Ribbon sprawl had moderate species diversity with a diversity index of D=1.4. the high diversity of crop species observed in the study is attributed to the fact that due to high rent on land in these areas, farmers form a kind of cooperatives whereby 10, 20 or more farmers acquire a plot of land and divide it into small interconnected farmlands amongst themselves depending on the amount of rent contributed by individual farmer and on the size of the acquired plot. Each farmer cultivates his specialty of crop(s). The interconnected farms with different cultivated crops creates a dense heterogeneous farm-scape that provides a variety of habitat that mimics the original landscape, making it suitable for faunal species such as birds, butterflies and bumblebees'. This connected fragments of variable farmlands accounted for the no significant difference in birds and bumblebees' species noted in Table 3. Thus, the implication of the findings in Table 4 is that the type of sprawl formation in an area affects the diversity of crops cultivated and faunal diversity in the area.

5. Conclusion

Findings from the study demonstrates that sprawl has significantly contributed to the reduced diversity of crop observed on peripheral agricultural lands in Nigeria, which has culminated in reduced diversity of birds, butterflies and bumblebees. Therefore, to maintain diversity of birds, butterflies and bumblebees on peripheral lands, agricultural lands should not be conceived as isolated landscapes by policy makers and planners, but rather as connected landscapes rich in per hectare crop cultivation that mimics the natural landscapes. The interconnected farms with diverse crops creates a dense heterogeneous farm-scape that provides a variety of habitat suitable for faunal species such as birds, butterflies and bumblebees'.

Table 4: Crop diversity and sprawl formations

Crops	Sprawl formations											
Commom name	**Ribbon sprawl**				**Leapfrog dev. Sprawl**				**Cont. dev. Sprawl**			
	F	Pi	logPi	-∑Pi logPi	F	Pi	LogPi	∑Pi logPi	F	Pi	logPi	-∑Pi logPi
Water leaf	1	.1	-2.303	.2	2	.06	-2.813	.2	1	.04	-3. 219	.1
Cocoyam	1	.1	-2.303	.2	2	.06	-2.813	.2	11	.04	-3.219	.1
Cassava	1	.1	-2.303	.2	2	.06	-2.813	.2	1	.04	-3.219	.1
Banana	0	0	0	0	1	.03	-3.507	0	2	.04	-3.219	.1
Maize	1	.1	-2.303	.2	2	.06	-2.813	.2	1	.08	-2.526	.2
Pawpaw	0	0	0	0	1	.03	-3.507	.1	1	.04	-3.219	.1
Bitterleaf	0	0	0	0	0	0	0	0	1	.04	.3.219	.1
Green	0	0	0	0	2	.06	-2.813	.2	2	.04	-3.219	.1
Pumpkin	1	.1	-2.303	.2	2	.06	-2.813	.2	1	.08	-2.526	.2
Melon	0	0	0	0	1	.03	-3.507	.1	1	.04	-3.219	.1
Tomatoes	0	0	0	0	1	.03	-3.507	.1	2	.04	-3.219	.1
Scentleaf	1	.1	-2.303	.2	3	.09	-2.248	.2	1	.08	-2.526	.2
Garden egg	0	0	0	0	2	.06	-2.813	.2	1	.04	-3.219	.1
Pepper	0	0	0	0	2	.06	-2.813	.2	1	.04	-3.219	.1
Sweet yam	0	.1	-2.303	.2	2	.06	-2.813	.2	1	.04	-3.219	.1
Plantain	1	0	0	0	2	.06	-2.813	.2	1	.04	-3.219	.1
Yam	0	0	0	0	1	.03	-3.507	.1	1	.04	-3.219	.1
Okro	0	0	0	0	0	0	0	0	1	.04	-3.219	.1
Cucumber	0	0	0	0	1	.03	-3.507	.1	1	.04	-3.219	.1
Curry leaf	0	0	0	0	1	.03	-3.507	.1	0	.04	-3.219	.1
Groundnut	0	0	0	0	1	.03	-3.507	.1	1	0	-3.219	.1
Water yam	0	0	0	0	0	0	0	0	0	.04	-3.219	.1
Mango tree	0	0	0	0	1	.03	-3.507	.1	0	0	0	0
Orange tree	0	0	0	0	1	.03	-3.507	.1	0	0	0	0
Sugar cane	0	0	0	0	1	.03	-3.507	.1	0	0	0	0
Indian snake tree	0	0	0	0	1	.03	-3.507	.1	0	0	0	0
Nim tree	0	0	0	0	1	.03	-3.507	.1	1	0	0	0
Milk tree	0	0	0	0	0	0	0	0	0	.04	-3.219	.1
	0	0	0	0	1	.03	-3.507	.1	1	0	0	0
TOTAL	7				37				25			
Diversity index				**1.4**				**3.2**				**0.25**

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