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Plant Diversity in Natural and Cultivated Hedgerows in the Laminga Area of Jos East, North Central Nigeria

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Abstract
Hedgerows are important semi-natural environments in agricultural landscapes. A study was carried in the Laminga Area of Jos East in North Central Nigeria to investigate the vegetation composition of farmland hedgerows and to compare plant species composition and diversity between natural and cultivated hedgerows. Twenty (20) farmland hedgerows (13 cultivated and 7 natural hedgerows) were sampled. At each farmland, sampling was conducted within a 50 x 1m area of the hedgerow. Plant species diversity was calculated using Shannon – Weiner's diversity index and plant species evenness was calculated using Pileou's evenness index. One-way-ANOVA was used to compare plant species richness, evenness and diversity between natural and cultivated hedgerows. The Plant community structure of the hedgerow types was characterized using Non-Metric Multidimensional Scaling (NMDS) ordination method. A total of 12,555 individual plants were recorded during the survey. These were divided into 100 species and 40 families. Plant species richness and evenness was not significantly different between the Natural and Cultivated hedgerows while the plant diversity was significantly higher in the Natural hedgerows than the Cultivated hedgerows. The hedgerows studied were prosperous in biodiversity. Hedgerows play several ecosystem functions and are highly important in conserving biodiversity.
Keywords: Agricultural landscapes, biodiversity, ecosystem, farmland, hedgerow, vegetation

1. Introduction

The development of the principles of landscape ecology and the corresponding increase in human-shaped landscapes has increased scientific attention to the composition, structure and functioning of the different types of farmland habitats (Forman, 2005; Kleijn and Verbeek, 2000). Within these semi-natural habitats, a central place is taken by Hedgerows or narrow bands of woody vegetation that separate adjacent fields (Forman and Baudry, 2004). A hedgerow has been defined as "any boundary line of trees or shrubs over 20m long and less than 5m wide at the base". A hedgerow can also be defined as "a line of one or more woody species, which may contain gaps and include associated vegetation of adjacent banks, ditches and/or field margins".

The failure to recognise the potential of agricultural and other disturbed landscapes early in biodiversity conservation has arguably led to their decline in quality. This is especially obvious at the local scale, where habitats within and beyond the agricultural landscapes have become increasingly fragmented while conservation efforts favour pristine landscapes (Tscharntke, *et al*., 2005). In recent years, however, it is increasingly being recognized that farm management is largely responsible for reversing the decline in biodiversity through habitat management (Kristensen, 2003).

Hedgerows are highly valued by people for many reasons. In the past, they were considered essential for marking ownership boundaries, and for keeping livestock in or out of fields (De Blois *et al*., 2002). Also, in time past and even today, hedgerows are used as a source of firewood, to shelter farm animals and crops. Other uses also include to screen unsightly development, provide privacy to homes and it could serve as a source for wild edible fruits. Also, Cattle, sheep and other livestock will often search out particular leaves and flowers from hedgerows to supplement their diet or to self-treat ailments - (Baudry *et al.*,2000).

Hedges deliver several ecosystem services besides these traditional functions (Baudry *et al*., 2000). The importance of hedgerows for the maintenance of ecological diversity and the sustainability of agricultural productivity is increasingly being emphasized by recent studies. These linear semi-natural habitats and their networks found in various agricultural landscapes throughout the world typically give a representation of the local biodiversity of the area (Tattersall *et al*., 2002; Hinsley and Bellamy, 2000). More so, in present-day landscapes, hedgerows often serve as a refuge for numerous species once widespread but now largely restricted to uncultivated field margins as a result of agricultural intensification, which has resulted in the decline of these species in the surrounding landscape (Robinson and Sutherland). Furthermore, hedgerows can also act as corridors for species migration from one suitable habitat patch to another in a fragmented landscape (Tischendorf *et al*., 1998).

Hedgerows are being threatened and this is in turn having a dramatic effect on the diversity of species that reside within or rely on these hedgerows; many of which are also facing decline from other pressures in their environment, worsening the situation (Hinsley and Bellamy, 2000). Such declines will have effects on the abundant services the hedgerow provides threatening agricultural sustainability.

Hedgerows are a part of our cultural heritage and historical records, and they have a great value to

wildlife and the landscape. Increasingly, they are valued too for the major role they play in preventing soil loss and reducing pollution, and for their potential to regulate water supply and to reduce flooding. This study records vegetation composition of hedgerows in the farmlands in Laminga areas of Jos-East, Plateau State. The specific objectives of the study are - To determine hedgerow plant species composition of farmlands in the Laminga Area; and - To compare plant species composition and diversity between natural and cultivated hedgerows.

2. Methodology

2.1 Study area

The study sites were the local farmlands in the Laminga area of Jos, Plateau State. These farmlands are located around the environs of Amurum Forest Reserve, a 300ha forest fragment located in Laminga village, 15km northeast of Jos, Plateau in North-Central Nigeria, at latitude 09˚53' N, longitude 08˚59' E, and at altitude of 1280m above sea level (Vickery and Jones, 2002).

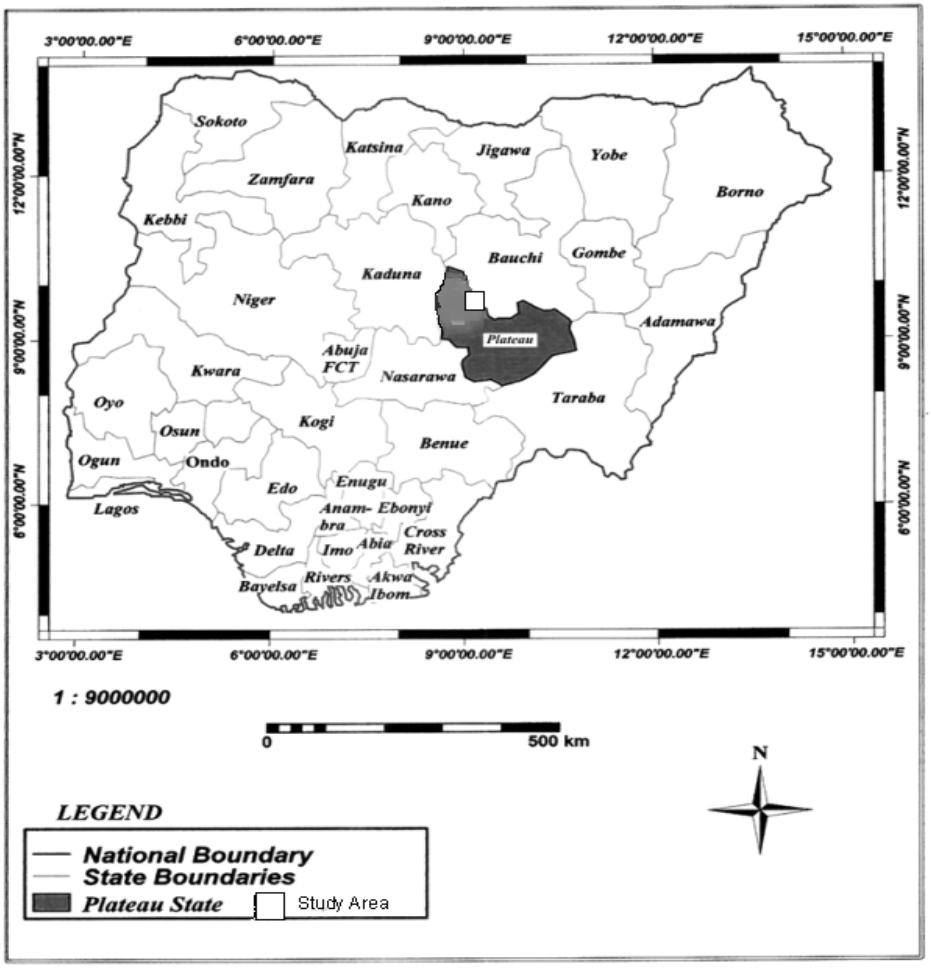

Figure 1: Map of Nigeria showing study area

2.2 Hedgerow sampling

Twenty (20) farmland hedgerows were sampled. Crops cultivated on these farmlands comprised *Arachis hypogaea* (Groundnut), *Manihot esculenta* (Cassava), *Dioscorea* sp. (Yam), *Colocasia esculenta* (Cocoyam), *Vigna unguiculata* (Cowpea), *Zea mays* (Maize), *Lycopersicon esculentum* (Tomato), *Digitaria exilis* (Acha), *Ipomoea batatas* (Sweet potato) and *Cucumis sativus* (Cucumber). At each farmland, sampling was conducted within a 50 x 1m area of the hedgerow. Plant identification was done using relevant texts (Hutchinson et al., 2014; Arbonnier, 2004). Plants that could not be identified on the field were collected and their features photographed so that they could be given future attention. Information was obtained from the land owners/farmers through an interview to ascertain their reasons for choosing particular species as hedges.

The hedgerows sampled gave a fair representation of the study area. The plots sampled were identified before sampling began to gain an overview of the site layout, access, land use and suitability of selected sampling areas. Land owners were informed of which hedgerows would require access using the base maps

before sampling took place to gain their permission.

Quantitative data was collected for each hedge during survey including hedgerow type, height and other notable features like species richness and relative occurrence.

2.3 Data Analyses

Data was compiled using Microsoft excel 2007® and analyzed using R Statistical Software Version 3.0.2 (R Development Core Team, 2013)

- Plant species diversity was calculated using Shannon – Weiner's diversity index, H.

$$H = -\sum_{i=1}^{S} P_i \ln P_i$$

Where Pi is the proportion of individual species and s is the total number of species in the community.

- Plant species evenness was calculated using Pileou's evenness index

J(evenness) = H/LnS

Where H= Shannon's Diversity index, S= Number of samples, and Ln= Natural log of the species number.

- One-way-ANOVA was used to compare plant species richness, evenness and diversity across the fields to assess variance between farms and hedgerows.
- Non-metric Multidimensional Scaling (NMDS) ordination method was used to characterize the Plant community structure of the farmlands. It is regarded as the most effective ordination method for ecology data. It was used to describe the pattern of plant species distribution.

3. Results

The studied area presents a wealth of flora. A total of 12,555 individual plants were recorded during the survey. These were divided into 100 species and 40 families (Table 1).

A total of 20 farm hedgerows were studied (13 Cultivated hedgerows and 7 Natural Hedgerows) with an average height of 4.6 meters. 11,350 plants were recorded in the cultivated hedgerows while 1205 plants were recorded in the Natural hedgerows. The results show no significant difference between the species richness and evenness but it shows a significant difference in the species diversity between the naturally occurring and artificial hedgerows.

Table 1: Plant Species recorded with their Families and Habit

S/N	PLANT SPECIES	FAMILY	HABIT
1	*Lannea schimperi* (Hochst. Ex A. Rich)	Anacardiaceae	Shrub/Tree
2	*Mangifera indica* L.	Anacardiaceae	Tree
3	*Rhus natalensis* Bernh. Ex Krauss.	Anacardiaceae	Shrub/Small Tree
4	*Annona senegalensis* Pers.	Annonaceae	Shrub/Small tree
5	*Uvaria chamae* P. Beauv.	Annonaceae	Shrub/Small Tree
6	*Steganotaenia araliacea* Hochest.	Apiaceae	Small Tree
7	*Ancylobotrys amoena* Hua.	Apocynaceae	Liana
8	*Carissa edulis* (Forssk.) Vahl.	Apocynaceae	Shrub/Small tree
9	*Holarrhena floribunda* (G. Don) T. Durand & Schinz	Apocynaceae	Shrub/Tree
10	*Saba comorensis* (Bojer ex A. DC.) Pichon	Apocynaceae	Shrub/Tree
11	*Phoenix dactylifera* L.	Arecaceae	Shrub/Tree
12	*Phoenix reclinata* Jacq.	Arecaceae	Shrub
13	*Agave sisalana* Perrine	Asparagaceae	Herb
14	*Asparagus africanus* L.	Asparagaceae	Climber
15	*Asparagus officinalis* L.	Asparagaceae	Climber
16	*Bidens pilosa* L.	Asteraceae	Herb
17	*Emilia abyssinica* Cass.	Asteraceae	Herb
19	*Emilia oleracea* Cass.	Asteraceae	Herb
20	*Guizotia abyssinica* (L.f.) Cass.	Asteraceae	Herb
21	*Guizotia scabra* (Vis.) Chiov	Asteraceae	Herb
22	*Synedrella nodiflora* (L.) Gaertn.	Asteraceae	Herb
23	*Vernonia perrottetii* Sch. Bip. Ex. Walp.	Asteraceae	Herb
24	*Commiphora africana* (A. Rich.) Endl.	Burseraceae	Small Tree
25	*Psorospermum febrifugum* Spach.	Clausiaceae	Shrub/Small Tree
26	*Gloriosa superba* L.	Colchicaceae	Herb/Climber

27	*Guiera senegalensis* J. F. Gmel	Combretaceae	Shrub
28	*Commelina benghalensis* L.	Commelinaceae	Herb
29	*Commelina diffusa* Burm. F.	Commelinaceae	Herb
30	*Santaloides afzelii* (R. Br.) Schellenb.	Connaraceae	Shrub
31	*Diospyros buxifolia* (Blume) Hiern	Ebenaceae	Tree
32	*Alchornea laxiflora* (Benth.) Pax & K.Hoffm	Euphorbiaceae	Shrub/Small tree
33	*Croton macrostachyus* Hochst. Ex. Delile	Euphorbiaceae	Tree
34	*Euphorbia hirta* L	Euphorbiaceae	Herb
35	*Euphorbia kamerunica* Pax	Euphorbiaceae	Shrub
36	*Euphorbia pentagona* Blanco	Euphorbiaceae	Shrub
37	*Euphorbia tirucalli* L.	Euphorbiaceae	Shrub/Small Tree
38	*Hymenocardia acida* Tul.	Euphorbiaceae (Phyllanthaceae)	Tree
39	*Jatropha curcus* L.	Euphorbiaceae	Shrub/Tree
40	*Manihot esculenta* Crantz	Euphorbiaceae	Shrub
41	*Ricinus communis* L.	Euphorbiaceae	Shrub
42	*Acacia ataxacantha* DC.	Fabaceae	Shrub/Climber
43	*Albizia zygia* (DC.) Macbr.	Fabaceae	Tree
44	*Chaemacrista rotundifolia* (Pers.) Green	Fabaceae	Herb
45	*Daniella oliveri* (Rolfe.) Hutch & Dalz.	Fabaceae	Tree
46	*Desmodium velutinum* (Willd.) DC.	Fabaceae	Shrub
47	*Dichrostachys cinerea* Wight et Arn.	Fabaceae	Shrub or Small Tree
48	*Erythrina sigmoidea* Hua.	Fabaceae	Shrub/Tree
49	*Indigofera tinctoria* L.	Fabaceae	Shrub
50	*Isoberlinia tomentosa* (Harms) Craib	Fabaceae	Tree
51	*Mucuna pruriens* (L.) DC.	Fabaceae	Herb
52	*Parkia biglobosa* (Jacq.) R. Br. Ex. G. Don	Fabaceae	Tree
53	*Piliostigma thonningii* (Schum.) Milne-Redh.	Fabaceae	Tree
54	*Senna Singueana* (Delile) Lock.	Fabaceae	Shrub/Small Tree
55	*Harungana madagascariensis* Lam. Ex Poiret	Hypericaceae	Tree
56	*Strychnos spinosa* Lam.	Loganiaceae	Tree
57	*Tapinanthus globiferus* (A. Rich) Tiegh.	Loranthaceae	Shrub
58	*Adansonia digitata* L.	Malvaceae	Tree
59	*Sida acuta* Burm.f.	Malvaceae	Herb
60	*Sida rhomboidea* Roxb. Ex Flem.	Malvaceae	Shrub
61	*Urena lobata* L.	Malvaceae	Shrub
62	*Ekebergia capensis* Sparm.	Meliaceae	Tree
63	*Khaya senegalensis* (Desr.) A. Juss.	Meliaceae	Tree
64	*Trichilia emetica* Vahl.	Meliaceae	Tree
65	*Dissotis rotundifolia* (Sm.) Triana	Melastomataceae	Herb
66	*Ficus benjamina* L.	Moraceae	Tree
67	*Ficus coronata* Spin.	Moraceae	Tree
68	*Ficus thonningii* Blume.	Moraceae	Tree
69	*Musa acuminata* Colla	Musaceae	Herb
70	*Syzygium guineense* Wall.	Myrtaceae	Tree
71	*Psidium guajava* L.	Myrtaceae	Shrub/Tree
72	*Ochna Schweinfurthiana* F. Hoffm	Ochnaceae	Shrub/Tree
73	*Jasminum dichotomum* Vahl.	Oleaceae	Shrub
74	*Biophytum sensitivum* L.	Oxalidaceae	Herb
75	*Bridelia ferruginea* Willd.	Phyllanthaceae	Shrub/Small tree
76	*Margaritaria discoidea* (Baill.) G. L. Webster	Phyllanthaceae	Tree
77	*Phyllanthus muellerianus* L.	Phyllanthaceae	Shrub
78	*Andropogon gayanus* Kunth	Poaceae	Grass
79	*Andropogon tectorum Schumach. & Thonn.*	Poaceae	Grass
80	*Cyperus esculentus* L.	Poaceae	Grass
81	*Digitaria exilis* (Kippist) Stapf	Poaceae	Grass

82	*Paspalum conjugatum* Bergius	Poaceae	Grass
83	*Sporobolus pyramidalis* Beauv.	Poaceae	Grass
84	*Setaria barbata* (Lam.) Kunth	Poaceae	Grass
85	*Setaria pallide-fusca* (Schumach.) Stapf. & C. E. Hubb.	Poaceae	Grass
86	*Clematis virginiana* L.	Ranunculaceae	Climber
87	*Ziziphus mucronata* Willd.	Rhamnaceae	Tree
88	*Diodia teres* Walter	Rubiaceae	Herb
89	*Keetia cornelia* (Cham. & Schltdl.) Bridson	Rubiaceae	Shrub
90	*Keetia venosa* (Oliv.) Bridson	Rubiaceae	Shrub
91	*Psychotria viridis* Ruiz & Pav.	Rubiaceae	Shrub
92	*Rytyginia decussata* (K. Schum.) Robyns	Rubiaceae	Shrub
93	*Clausena anisata* (Willd.) Hook. f. ex Benth.	Rutaceae	Shrub or Small tree
94	*Allophylus africanus* P. Beauv.	Sapindaceae	Tree
95	*Paullinia pinnata* L.	Sapindaceae	Liana
96	*Vitellaria paradoxa* C. F. Gaertn	Sapotaceae	Tree
97	*Triumfetta cordifolia* A. Rich	Tiliaceae	Shrub
98	*Lantana camara* L.	Verbenaceae	Shrub
99	*Vitex doniana* L.	Verbenaceae	Tree
100	*Cissus tuberosa* L.	Vitaceae	Climber

3.1 Mean Plant Species Richness

The mean plant species richness was not significantly different (F=0.4815; df=1; p=0.4966) between the natural and cultivated hedgerows (Figure 2).

3.2 Mean Plant Species Evenness

The mean plant species evenness did not significantly differ (F=0.6572; df=1; p=0.4282) between the Natural and cultivated hedgerows sampled (Figure 3).

3.3 Mean Plant species diversity of the Natural and Cultivated Hedgerows

The mean plant species diversity differed significantly (F=7.492; df=1; p=**0.0135**) between the Natural and Cultivated Hedgerows. The Natural Hedgerows had a higher mean plant species diversity than the Cultivated Hedgerow (Figure 4).

3.4 Plant community structure of the Farmlands in the Laminga Area

Non-metric multidimensional Scaling (NMDS) ordination resulted in a 2-axis optimal solution.

The ordination plot shows the relative similarity and dissimilarity of plant species communities at the study site seen in the overlapping and close points indicating similar plant assemblages in these stations or the separated points indicating different plant assemblages respectively (Figure 4).

Figure 2: Mean plant species richness within the Natural and Cultivated Hedgerows

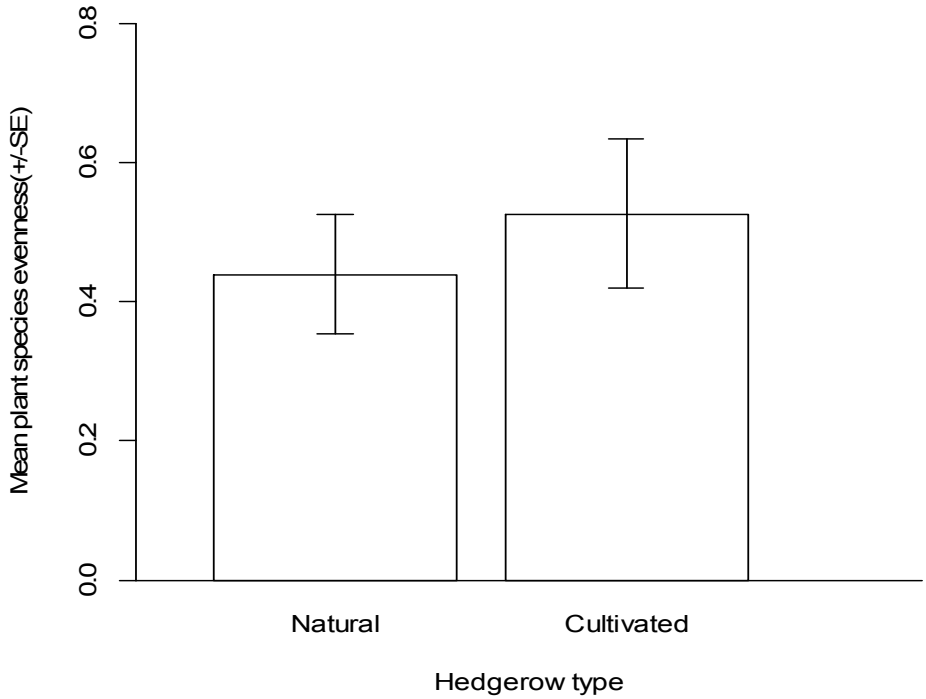

Figure 3: Mean plant species evenness within the Natural and Cultivated Hedgerows

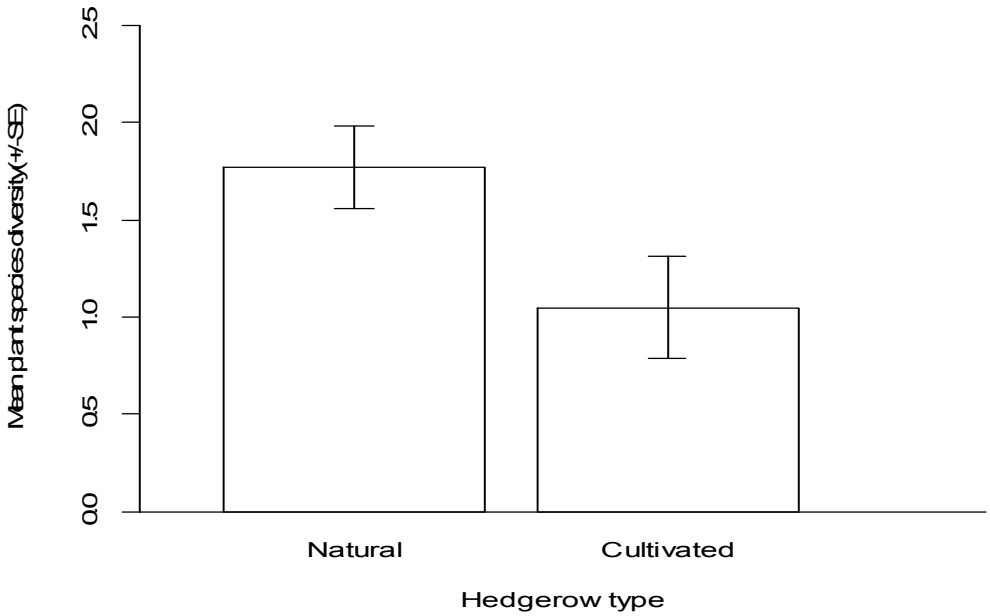

Figure 4: Mean plant species diversity within Natural and Cultivated Hedgerows

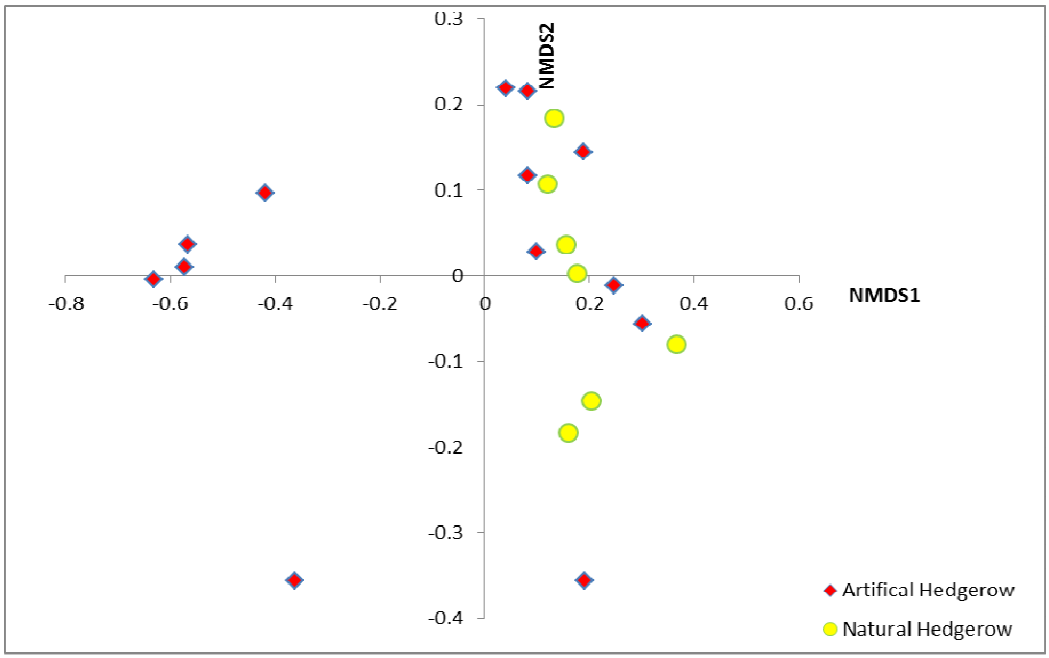

Figure 5: Ordination plot of sampling points along non-metric multi-dimensional scaling (NMDS) axes 1 (x-axis) and 2 (y-axis)**. (**Sampling points more close together are more similar in their plant species composition).

4. Discussion

A total of 100 plant species from 40 families were encountered. The most common families encountered were Fabaceae, Euphorbiaceae, Poaceae, Asteraceae, Rubiaceae, Apocynaceae and Malvaceae. The study identified the Fabaceae, Malvaceae and Asteraceae as the most represented families in the tree vegetation of the study area. Other substantially represented were the Euphorbiaceae, Poaceae and Rubiaceae.

This is in close agreement with the work of Bonlin *et al.* (2002) who recorded that overall plant diversity was higher in natural hedgerows and they also contained more plant species of conservation values than other hedgerow types.

Floristic composition, species richness and evenness were not significantly different between the Natural & Artificial Hedgerows (Figures 2 & 3). This could be accredited to the relatively close proximity of the

farms having Natural hedgerows and those having cultivated hedgerows.

There was significant difference in the species diversity in the Natural and Cultivated hedgerows (Figure 4). Plant species diversity was significantly higher in the Natural hedgerows than the cultivated hedgerow (Figure 4). This could be due to the fact than the natural hedgerows in most cases have lasted longer than the artificial hedgerows without undue human interferences. This is also in agreement with the work of Huston (1994) which affirms that a moderate level of disturbance maximizes the diversity of species in any habitat. Also, according to Hedgelink (2008), natural/undisturbed habitat tend to have high flora and fauna diversity.

Plant diversity in ecosystems and agricultural landscapes determine the occurrence of many fauna. These components provide several ecosystem services. For example, the play a role in microclimate and protection, they limit the effects of extreme weather events, soil degradation, pollution, greenhouse gas emissions, etc. (Maudsley, 2000).

The NMDS ordination presented in Figure 5 illustrates the similarity of plant communities in terms of Natural & cultivated hedgerows and plot. The ordination plot revealed a grouping of sampling stations for the Natural and cultivated Hedgerows (Figure 5) whose sampling points clustered separately as observed by their positions on the ordination plot. The stations of the Natural Hedgerows where more clustered while those of the cultivated hedgerows were more spread out on the ordination plot. Studies have shown that the differences in plant community structure are reflection of the ecological characteristics of the area (Abiem, 2013).

5.Conclusions and Recommendations

The hedgerows studied were prosperous in biodiversity and being the first floristic study of hedgerows in the region, it shows the importance of the region in terms of plant diversity. The study has been able to show that plant species richness and evenness is not significantly different between the Natural and Cultivated hedgerows while the plant diversity is significantly different with the Natural hedgerows having a higher diversity (Fig 4).
Interactions with the some of the local farmers provided clue as to the reason for their choice of certain plants especially members of the Euphorbiaceae as hedgerows. The information is summarized below:

i. The plants are readily available, cheap and suitable.
ii. Most plants used as hedges are offensive in nature i.e. having thorns, spines etc. that can serve as a fence to ward off intruders like herbivores.
iii. Most of these plants like *Euphorbia* spp are easy to propagate vegetatively through cuttings and they were succulents that did not require any special care such as watering once they are planted.
iv. Most of the farmers said that plant species of the family Euphorbiaceae especially *Euphorbia kamerunica* and *Euphorbia pentagonia* were their cultural heritage handed down to them by their fore-fathers.

Further research needs to be carried out to address the dynamics of plant community complexities in order to provide explanations for the observed structural characteristics of the hedgerows. A detailed study into the functional diversity of the plant species will be useful in recognizing the most important plant species in terms of native species of the area. The study suggests that hedgerows need to be protected and retained.

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