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Traditional agroforestry practices and woody species conservation in the derived savanna ecosystem of Adamawa state, Nigeria

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ABSTRACT Agroforestry practices are known to contribute to food security, environmental protection and biodiversity conservation. To determine the extent of contribution of some traditional agroforestry practices to woody species conservation, data were collected from the natural fallow land, grazing land and natural forest in and around the Gumti sector of Gashaka-Gumti National Park, covering Toungo and Jada local government areas of Adamawa State, Nigeria. The area was sampled in a group of twelve 0.04 ha (20 m × 20 m) plots per land use type. All woody plants with diameter at breast height greater than or equal to 5 cm were identified. A total of 0.48 ha of natural fallow, grazing land and natural forest were surveyed. 361 individuals belonging to 27 taxa and 16 families were identified in the 0.48 ha of natural forest surveyed. In the natural fallow, 314 individuals belonging to 32 taxa in 16 families were encountered while the grazing land had 211 individuals belonging to 23 taxa in 16 families. The natural forest had the highest density of woody species (752.08 plants/ha) while the lowest (439.58 plants/ha) was observed on the grazing land. The values of Shannon diversity index differ significantly among the land use types with the natural forest having the highest (0.85), while the grazing land the least (0.56). The rarefaction curves, however, indicated that the grazing land had the highest species richness relative to the total number of individuals encountered.

KEY WORDS Agroforestry; natural fallow; forest; grazing land; woody species conservation.

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INTRODUCTION

Among the major challenges facing the world today are deforestation, land degradation, unsustainable farming practices, loss of biodiversity, increased risks of climate change and rising hunger, poverty and malnutrition. Agroforestry has been identified as a land-use option that can address many of these global challenges. Deliberate inclusion of trees in agricultural landscapes has been a common practice among farmers for a very long time and the farming communities have played important roles in conserving crop and tree diversity.

Although the traditional agroforestry practices have contributed immensely to food security and environmental protection, the need to meet the increasing needs of the burgeoning population has led to the development of modern agroforestry practices with simplified ecosystem structure and consequent destruction of biological diversity. In recent times, scientists have become interested in the environmental services that agroforestry practices

may provide to local and even global society by maintaining watershed functions, retaining carbon in the plant-soil system, and by supporting the conservation of biological diversity (McNeely & Scherr, 2003; Schroth et al., 2004). Greater attention is now being paid to those complex tree-based traditional practices that are so widespread in traditional tropical land use.

The natural environment in the savanna ecosystem is characterized by a combination of trees and grasses in different proportions. Farmers in the West African savannas maintain valuable trees, which also resist periodical fires in and around their fields giving rise to distinct park like landscape (Boffa, 1999). Scattered trees on farmland/pasture and bush fallowing are the common traditional agroforestry practices in the savanna ecosystem of Nigeria (Oboho & Anyia, 1992; Chup, 2004). Traditionally farmers grow crops under scattered trees of different species and they sometimes incorporate animal production with no special technique, species type or density per unit area. The trees are allowed to grow and they appear scattered over the farm. Many farmers in these areas also practice shifting cultivation which is the alternation of cropping periods with those of fallow.

Agroforestry systems in areas surrounding protected areas can reduce biodiversity loss, restore degraded areas, and integrate local cultural practices and economic needs into biodiversity conservation (Nair et al., 2005; Mcneely & Schroth, 2006; Ashley et al., 2006; Bhagwat et al., 2008). Many agroforestry systems have been studied for their roles in biodiversity conservation. There have been reports on biodiversity conservation in shade coffee agroforestry system (Perfecto et al., 1996; Moguel & Toledo, 1999), multistrata cocoa agroforestry (Oke & Odebiyi, 2007; Harvey & Gonzalez-Villalobos, 2007) and homegarden agroforests (Ewel, 1999). In a survey of floristic diversity of 402 home gardens from six regions across southwestern Bangladesh, Kabir & Webb (2009) reported 419 species including six species of conservation concern.

A study conducted by Backes (2001) on the contribution of agroforestry land use to the in-situ conservation of indigenous trees within a typical East African smallholder farming system in western Kenya shows how species diversity is ultimately linked to the loss of habitat diversity and landscape diversity. Fifanou et al. (2011) recorded twenty-one tree species belonging to 14 botanical families during the survey of traditional agroforestry parkland systems around the Pendjari Biosphere Reserve in Benin.

The present study seeks to evaluate the conservation values of the major traditional agroforestry practices in a derived savanna ecosystem of Nigeria.

MATERIALS AND METHODS

Study site

The study was carried out in and around Gumti sector, in the northern half of Gashaka-Gumti National Park, covering Toungo and Jada local government areas of Adamawa State. Gashaka-Gumti National Park (GGNP) is located on latitude 6°55′-8°13′N and longitude 11°13′-12°25′E. The Park is made up of the Gashaka sector in the southern half of the park, and Gumti sector in the Northern half. The Northern sector of the Gashaka-Gumti National Park consists of derived Savannah with forest fringing along streams, steep valleys and on mountain line. The rugged terrain is characterized by steep, thickly forested slopes, deep plunging valleys, precipitous escarpments and swiftly flowing rivers. Altitude is about 450 meters above sea level.

The area receives an annual rainfall of 1000-1200 mm. Rainfall distribution is unimodal, with much of the rain falling between April and November. Day time temperatures may drop below 18°C at higher altitudes and gradually rise to 40°C. The rainy season is followed by a dry season. During this period, the area comes under the strong influence of the hammattan (November and March), a dry dusty wind blowing from Sahara Desert, and temperatures may be significantly cooler (GGNP, 2010).

Experimental Design

Three land use types - undisturbed natural forest, grazing land, and abandoned natural fallow - were identified around the Gumti side of the park. Three transect lines were cut through the natural forest and grazing land at a minimum distance of 100 m apart. Four sampling plots of 20 m × 20 m in size were laid in alternate pattern along each transect at 50 m intervals. Four abandoned fallow (8-10 years of natural fallow) were selected from the encroa-

ched area very close to the Forest Reserve. Three 20 m x 20 m plot was demarcated within the centre of each fallow land and data were collected from each plot. Assessment of tree diversity was done in sample plots demarcated within each land use type and also on 20 m × 20 m demarcated within four natural fallow lands in the fringe settlements

With the assistance of an experienced taxonomist, all woody species (diameter at breast height, dbh ≥ 5 cm) encountered in each of the demarcated sample plots were identified and their frequency of occurrence recorded. For unknown tree species, leaves, slash and bark of such trees were collected and taken to the herbarium for identification. The total number of each tree species encountered in the twelve sample plots (0.48 ha) for each ecosystem was calculated (frequency) and the figure was used in estimating number of trees per hectare (tree density). Species diversity was calculated as $H' = -\sum\{(n_i/N)\log_e(n_i/N)\}$, where H' = Shannon index of general diversity, n_i = number of individuals of a species, N = total number of individuals in the community.

Data Analysis

Values of Shannon diversity indices and tree density of the three types of plant communities were compared using ANOVA. The rarefaction method (Gotelli & Colwell, 2001) was used to generate the expected number of species in natural fallow, grazing land and natural forest. The free software EstimateS 8.0 (Gotelli, 2006) was used to generate data for the construction of sample-based rarefaction curves and confidence intervals for species richness after re-scaling the x-axis to individuals.

RESULTS

Three hundred and sixty one individuals belonging to 27 taxa and 16 families were identified in the 0.48 ha of natural forest surveyed (Table 1). The richest families were Fabaceae and Combretaceae which had five species each. Families Rubiaceae, Euphorbiaceae and Caeselpiniaceae had two species each. The predominant 10 woody species present in the natural forest accounted for 85% of total population. They included *Detarium microcarpum*, *Lophira lanceolata*, *Hymenocardia acida*, *Crossopteryx febrifuga*, *Burkea africana*, *Bridelia ferruginea*, *Terminalia glaucescens*, P*rosopis africana*, *Annona senegalensis* and *Daniella oliveri*.

In the 0.48 ha of the natural fallow surveyed, 314 individuals belonging to 32 species in 16 families were encountered (Table 2). The richest families were Fabaceae (ten species) and Combretaceae (six species). The dominant woody species were *Philiostigma thonningii*, *Acacia gourmaensis*, *Anogeissus leiocarpus*, *Pteleopsis habeensis*, *Strychnos innocua*, *Combretum molle*, *Boswellia dalzielii* and *Dichrostachys cinerea*. In the 0.48 ha of the grazing land surveyed, 211 individuals belonging to 23 taxa in 16 families were encountered (Table 3). The richest family was Combretaceae which had five species. Family Meliaceae had three species, Fabaceae two species. The dominant woody species were *Anogeissus leiocarpus*, *Philiostigma thonningii*, *Combretum molle*, and *Vitellaria paradoxa*.

The natural forest had the highest density of woody species (752.08 plants/ha) while the lowest (439.58 plants/ha) was observed on the grazing land. Woody species diversity was also significantly higher in the natural forest indicating a greater variety of species (Table 4). The rarefaction curves (Fig. 1) also indicate that the natural forest supports a species richness relatively higher than floristically and climatically similar sites of grazing land and natural fallow.

DISCUSSION

This study reveals that a large number of woody species occur in the traditional bush fallow system and scattered trees on grazing land systems of the derived guinea savanna ecosystem of Adamawa State, Nigeria. However a modification of the species composition was observed in both the grazing land and natural fallow with more pioneer species and different dominant species compared with the natural forest. *Anogeissus leiocarpus* and *Philiostigma thonningii* were the dominant woody species in both the natural fallow and the grazing land systems as opposed to *Detarium microcarpum* which dominated the natural forest. The dominance of *Anogeissus leiocarpus* in the natural fallow and the grazing land systems may not be unconnected with its attribute as a pioneer species which grows well in open forest clearings. Moreover, farmers might have deliberately retained the species because of its

SPECIES	FAMILY	FREQUENCY	DENSITY (TREES/HA)
Detarium microcarpum Guill et Sperr	Caeselpiniaceae	87	181.25
Lophira lanceolata Tiegh. ex Keay	Ochnaceae	43	89.58
Hymenocardia acida Tul.	Euphorbiaceae	37	77.08
Crossopteryx febrifuga (Afzel. ex G.Don) Benth.	Rubiaceae	34	70.83
Burkea africana Hook.	Caeselpiniaceae	29	60.42
Bridelia ferruginea Benth.	Euphorbiaceae	23	47.92
Terminalia glaucescens Planch. ex Benth.	Combretaceae	20	41.67
Prosopis africana (Guill. et Perr.) Taub. 1893	Fabaceae	15	31.25
Annona senegalensis Pers.	Annonaceae	10	20.83
Daniella oliveri (Rolfe) Hutch et Dalziel	Fabaceae	9	18.75
Parinari excelsa Sabine	Chrysobalanaceae	7	14.58
Piliostigma thonningii (Schumach.) Milne-Redh.	Fabaceae	7	14.58
Maytenus senegalensis (Lam.) Exell	Celastraceae	6	12.50
Lannea acida A. Rich.	Anacardiaceae	5	10.42
Anogeissus leiocarpa (DC.) Guill. et Perr.	Combretaceae	4	8.33
Ficus sp.	Moraceae	4	8.33
Entada africana Guill. et Perr.	Fabaceae	3	6.25
Pericopsis laxiflora (Benth.) Meeuwen	Papilionaceae	2	4.17
Securidaca longipedunculata Fresen.	Polygalaceae	2	4.17
Bombax costatum Pellegr. et Vuill.	Malvaceae	1	2.08
Boswellia dalzielii Hutch.	Burseraceae	1	2.08
Combretum gabonense Exell	Combretaceae	1	2.08
Combretum glutinosum Perr. ex DC.	Combretaceae	1	2.08
Combretum sp.	Combretaceae	1	2.08
Nauclea latifolia Smith	Rubiaceae	1	2.08
Pterocarpus erinaceus Poir.	Fabaceae	1	2.08
Vitex simplicifolia Oliv.	Verbanaceae	1	2.08
		361	

Table 1. Diversity of tree/shrub species in the 0.48 ha of Natural forest in the derived savanna ecosystem of Adamawa State.

SPECIES	FAMILY	FREQUENCY	DENSITY (TREES/HA)
Philiostigma thonningii (Schum.) Milne-Redh	Fabaceae	81	168.75
Anogeissus leiocarpus (DC.) Guill. et Peer.	Combretaceae	57	118.75
Acacia gourmaensis A. Chev.	Fabaceae	27	56.25
Pteleopsis habeensis Aubrev. ex Keay	Combretaceae	19	39.58
Strychnos innocua Delile	Loganiaceae	17	35.42
Combretum molle R.Br. ex G.Don	Combretaceae	15	31.25
Boswellia dalzielii Hutch.	Burseraceae	12	25.00
Dichrostachys cinerea (L.) Wight et Arn.	Mimosaceae	12	25.00
Annona senegalensis Pers.	Annonaceae	7	14.58
Acacia nilotica (L.) Willd. ex Delile	Fabaceae	6	12.50
Combretum glutinosum Perr. ex DC.	Combretaceae	6	12.50
Ziziphus mauritiana Lam.	Rhamnaceae	6	12.50
Acacia sp.	Fabaceae	5	10.42
Daniella oliveri (Rolfe) Hutch et Dalziel	Fabaceae	5	10.42
Diospyros spp	Ebenaceae	5	10.42
Entada africana Guill et Perr.	Fabaceae	5	10.42
Acacia ataxacantha DC.	Fabaceae	4	8.33
Combretum gabonense Exell	Combretaceae	4	8.33
Combretum sp.	Combretaceae	3	6.25
Gmelina arborea Roxb. ex Sm.	Lamiaceae	3	6.25
Vitellaria paradoxa C.F.Gaertn.	Sapotaceae	3	6.25
Isoberlinia doka Craib et Stapf.	Fabaceae	2	4.17
Acacia polyacantha Willd.	Fabaceae	1	2.08
Bombax costatum Pellegr. et Vuill.	Malvaceae	1	2.08
Crossopteryx febrifuga (Afzel. ex G. Don)	Rubiaceae	1	2.08
Detarium microcarpum Guill et Sperr	Caeselpiniaceae	1	2.08
Hymenocardia acida Tul.	Phyllanthaceae	1	2.08
Lannea schimperi (Hochst. ex A. Rich.) Engl.	Anacardiaceae	1	2.08
Parkia biglobosa (Jacq.) R.Br. ex G. Don.	Fabaceae	1	2.08
Pseudocedrela kotschyi (Schweinf.) Harms.	Meliaceae	1	2.08
Sterculia setigera Del.	Malvaceae	1	2.08
Ziziphus abyssinica Hochst. ex A.Rich.	Rhamnaceae	1	2.08
		314	

Table 2. Diversity of tree/shrub species in the 0.48 ha of natural fallow in the derived savanna ecosystem of Adamawa State.

SPECIES	FAMILY	FREQUENCY	DENSITY (TREES/HA)
Anogeissus leiocarpus (DC.) Guill. et Perr.	Combretaceae	120	250.00
Piliostigma thonningii (Schum.) Milne-Redh.F	Fabaceae	18	37.50
Combretum molle R. Br. ex G. Don	Combretaceae	11	22.92
Vitellaria paradoxa G.F. Gaertn.	Sapotaceae	12	25.00
Detarium microcarpum Guill et Sperr	Caeselpiniaceae	9	18.75
Combretum sp.	Combretaceae	6	12.50
Azadirachta indica A. Juss.	Meliaceae	4	8.33
Combretum glutinosum Perr. ex DC.	Combretaceae	4	8.33
Lannea schimperi (Hochst. ex A. Rich.) Engl.	Anacardiaceae	4	8.33
Pseudocedrela kotschyi (Schweinf.) Harms	Meliaceae	4	8.33
Bombax costatum Pellegr. et Vuill.	Bombacaceae	3	6.25
Acacia polyacantha Willd.	Fabaceae	2	4.17
Combretum gabonense Exell	Combretaceae	2	4.17
Dalbergia sissoo Roxb. ex DC.	Papilionaceae	1	2.08
Bridelia ferruginea Benth.	Euphorbiaceae	1	2.08
Crossopteryx febrifuga (Afzel.ex G.Don)Benth.	Rubiaceae	1	2.08
Ficus sp.	Moraceae	1	2.08
Khaya senegalensis (Desr.) A.Juss.	Meliaceae	1	2.08
Maytenus senegalensis (Lam.) Exell	Celastraceae	1	2.08
Parinari excelsa Sabine	Chrysobalanaceae	1	2.08
Prosopis africana (Guill. et Perr.) Taub.	Mimosaceae	1	2.08
Strychnos innocua Delile	Loganiaceae	1	2.08
Ximenia americana L.	Oleaceae	1	2.08
		211	

Table 3. Diversity of tree/shrub species in the 0.48 ha of grazing land in the derived savanna ecosystem of Adamawa State.

usefulness as a fodder species. The species has also been found very useful for various other purposes such as carving and firewood production, provision tanning and dyeing materials and medicinal application (Sacande & Sanago, 2007). *Philiostigma thonningii* is also a very useful fodder species which produces edible leaves, fruits and seeds. Its versatility as soil improver and provider of shade and many useful products might have accounted for its deliberate retention on the fields by farmers.

Another woody species that was common to the natural fallow and grazing land of the study area is

	TOTAL NO OF TREES/SHRUBS	TREE/SHRUB DENSITY (N/HA)	DIVERSITY INDEX
FOREST	361	752.08	0.85a
GRAZING	211	439.58	0.56c
FALLOW	314	654.17	0.76b

Table 4. Density and diversity indices of trees/shrubs in natural forest, grazing land and natural fallow ecosystems in the derived savanna ecosystem of Adamawa State. Means of diversity index followed by same letters are not significantly different ($P < 0.05$).

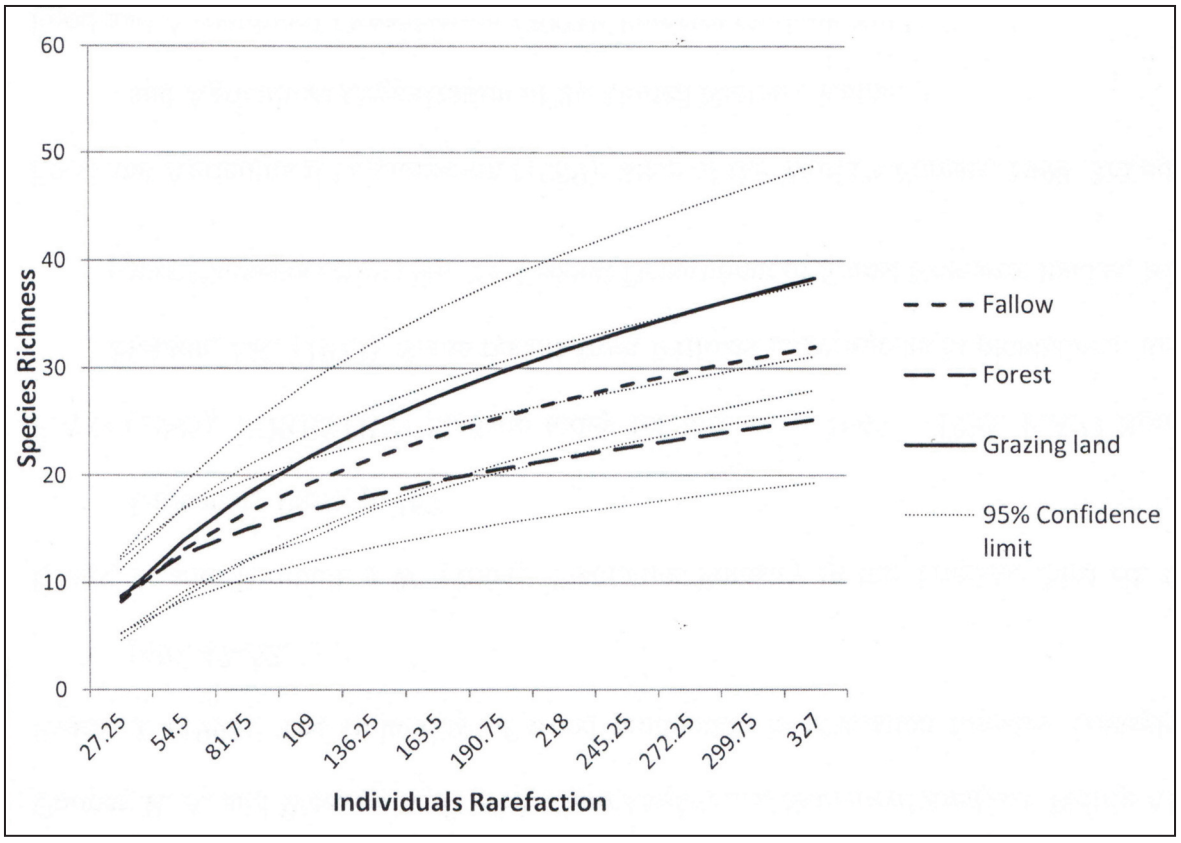

Figure 1. Woody species richness in natural forest, natural fallow and grazing land ecosystems in Gumti area, Nigeria. Individual rarefaction curves and confidence intervals.

Combretum molle. It is an important fodder species whose leaves are browsed by cattle. Its wood is very good for firewood, it produces good quality charcoal and various parts of the plant have been found to be of important medicinal value. The high density of woody species recorded in all sites in this study may be attributed to the use of 5 cm minimum diameter at breast height and the inclusion of shrub species in the enumeration. Expectedly, tree/shrub density was highest in the natural forest while the grazing land had the least value. Although the agroforestry plots contained a large variety of woody species, Shannon index indicated that they show a lower species diversity than the natural forest.

The rarefaction curves in this study indicated that the grazing land had the highest species richness followed by the natural fallow while the least was in the natural forest. This appears to negate the results of Shannon's indices. This may not be unconnected with the fact that there were more individuals in the natural forest relative to the number of different species. Gotelli & Colwell (2001) emphasized the importance of using taxon sampling curves (both individual- and sample-based) to standardize datasets to a common number of individuals for the purpose of comparing species richness.

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