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Full Length Research Paper

Trees species diversity in perennial crops around Yapo protected forest, Côte d'Ivoire

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The potential of agricultural landscapes for tree species diversity conservation in perennial crop was examined in the Southeast of Côte d'Ivoire. Based on botanical survey of trees and shrubs species, the beta diversity has been assessed and diversity profile, species accumilation curves, and rank abundance have been compared from 70 plots of 500 m^2 selected in the Yapo Protected Forest (YPF), a Voluntary Natural Reserve (VNR), the Community Forests (CF) and the four main crop systems: cocoa (*Theobroma cacao*), cola (*Cola nitida*), teck (*Tectona grandis*) and rubber (*Hevea brasiliensis*). Results show that 7.3% of stems recorded in old forests can be met in all types of farm habitats. The YPF is more diverse than the other habitats. VNR, CF, and cola-cocoa-rubber farms have the same trees species diversity level when we considered only the most abundant spceies. Farms of rubber contribute to decreasing tree species diversity. In all habitat types, most species are scarce. The highly abundant species are non pioneer species in YPF and VNR, pioneer species in CF and exotic species in farms. A substantial number of tree species can be found on farms that is increasing beta diversity in the study area. Further researches are required to determine the drivers of these results in the study area.

Key words: Agroforestry, diversity profile, farmland, old growth forest, Côte d'Ivoire.

INTRODUCTION

Tropical forests are under serious threats. These important habitats, sustaining the majority of all species found on earth, are being rapidly degraded by many human activities (Gibson et al., 2011). Because of these constant threats on tropical biodiversity, many authors have recommended the practices of trees integration in farming systems (Nair, 1993; Somarriba et al*.,* 2013; Kpangui et al., 2015; Vroh et al., 2015a).

Indeed, trees integration in farming systems plays a very important role in tropical biodiversity conservation (Perfecto et al., 1996; Albertin and Nair, 2004; Rice, 2008; Correia et al., 2010). These systems also provide forest goods and production services such as food, fuel, and medical security, especially during hunger periods for low-income rural people (Arnold and Dewees, 1995; Arnold, 1997). Many studies showed also that the introduction of trees in farming systems would participate in the conservation of the local diversity, and in the fight

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against the global warming (Rice and Greenberg, 2000; Bhagwat et al., 2008). For example, researches across the tropics show that integration of trees species in farms can have as few as one canopy tree species by hectare and up to 64 species by hectare (Carlo et al., 2004). In Côte d'Ivoire, according to Kpangui et al. (2015), this practice plays a very important role in biodiversity conservation in cocoa production systems in forest-savanah contact zone. In Guinea, trees species richness integrated in coffee farms resembles that of many secondary forests (Correia et al., 2010).

The process of trees introduction in farms is usually called agroforestry. That is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land management unit as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequences such that there are significant ecological and economic interactions between tree and agricultural components (Lundgren and Raintree, 1982).

However, it is important not to restrict agroforestry practices to the integration of woody and non-woody components, since some plants generally labeled as agricultural crops are themselves woody, particularly the plantation tree crops such as tea, rubber, teak, cola, coffee and cacao (Sinclair, 1999). So, agricultural use of trees, where there is a frequent, regular and multiple harvest, can be then, most usefully classified as agroforestry. In other words, each of the specific tree crop types can also be considered as different agroforestry system. Classification of major types of agroforestry practices is then, based primarily on the components involved and the predominant uses of land (Nair, 1985). The arrangement, density and diversity of the tree component involved are secondary factors in the classification scheme.

In agroforestry systems, these introductions of trees on farms can result from three processes defined by Ordonez et al. (2014). The first process is about the maintenance of trees that were present before farms were established. In this context, remnant trees from forest are selected for their utility and low interferance with crops. The second process is about the tolerance (and protection) of natural tree regeneration after farms were established. This process concerne spontaneously regenerated trees selected for their effective dispersal and presence of mother trees in the farms. The last process concerne active planting by farmers of selected trees in preferred locations. For this last process, planted trees are selected for their availability and expected utility. Many agricultural landscapes include trees derived from more than one of these processes in tropical area. This sequence of processes has become known as the tree cover transition curve (van Noordwijk et al., 2011).

Cultivating trees, agricultural crops and pastures in combination with the same managment unit is an ancient practice that farmer have used throughout the forest zone of Côte d'Ivoire (Adou Yao, 2005). In Azaguié area (Southeast of Côte d'Ivoire), there are many perennial crop types cultivated according to farmers' empirical practrices (Vroh, 2013). Among these crop farms, cocoa (*Theobroma cacao*), cola (*Cola nitida*), teck (*Tectona grandis*) and rubber (*Hevea brasiliensis*) take the larger place in the landscape. For the local farmers, the primary purpose of land usage is to provide sustenance and income from agricultural crops. Considering Nair (1985) and Sinclair (1999), these plantation tree crops where there is a frequent, regular and multiple harvest, can be classified as different agroforestry systems. But, the trees diversity potential implications of these four different perennial crops in forest tree species diversity conservation is not known. It is critical to understand the impact of these various crop types on trees species conservation in order to mitigate those activities that are damaging more and to identify those farm types that offer the greatest potential for restoration in the farming systems.

The purpose of this study is then to assess diversity and abundance of the tree components involved in these crop farms. The reflexion was based on the three processes of the sequence defined by Ordonez et al. (2014) in the four main different perennial crop types: cocoa, cola, rubber and teak. The tree cover transition curve defined by van Noordwijk et al. (2011) was used considering trees species diversity in the four farms types. The study aims to answer the two following questions:

(1) Do the interventions of the farmers contribute always to the decline (negative effects) or increase (positive effects) to trees diversity and abundance in the farms comparatively to different old forest types?
(2) What are the characteristics for substantial trees species on cocoa, cola, rubber, and teak farms in the study area?

Answering these questions allowed us to assess the contribution of these farm types to trees (native and exotic) conservation around Yapo Protected Forest (YPF) in the Southeast of Côte d'Ivoire. Specifically, the study has :

(1) Determined tree species diversity profile in each farm types;
(2) Compared these profiles to those obtained in old forests such as YPF, a Voluntary Natural Reserve (NVR) site, and Community Forests (CF), and finally
(3) Analysed the effectiveness of trees restoration efforts by farmers in these traditional farms.

These objectives can help understand the empirical management of agricultural landscapes by farm smallholders in rural area and the conservation of trees by traditional practrices.

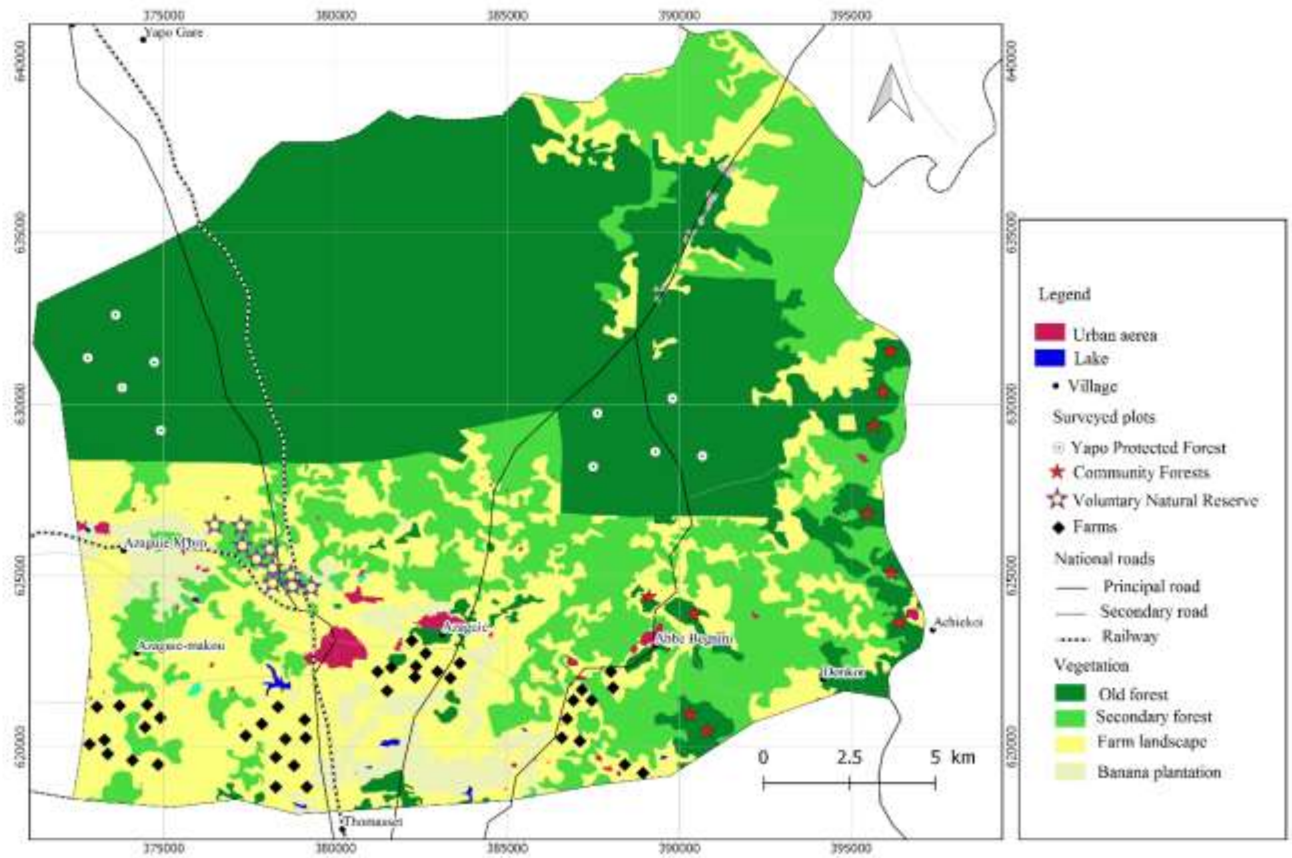

Figure 1. Map of land use and location of surveyed plots in Aaguie area.

METHODOLOGY

Description of the study area and sites

The study took place around the locality of Azaguié in the Southeast of Côte d'Ivoire (Figure 1). Rainfall and temperature database from 1996 to 2009 show that climate regime for this area had four seasons: two dry and two rainy seasons. The duration of the dry season was less than 5 months. Annual rainfall varied between 1,500 and 2,000 mm. In 1907, Chevalier was the first botanist who inventoried in this area (Corthay, 1996). The vegetation of the area is characterized by *Diospyro-Mapanietum* association (Mangenot, 1955). The main vegetation is evergreen rainforest (Guillaumet, 1967) that is being replaced by disturbed habitats such as farms, fallows and secondary forests.

In the area, four habitats types have been selected : YPF, a VNR, CF, and crops. The three forest are differently managed. YPF with 24 592 ha of area, is one of the largest and the only block of the rainforest remains in area of Azaguié. It was subjected to logging with enrichment in some compartments (experimental plots) which resulted in changes in its vegetation and natural flora (Corthay, 1996). These enhancements have contributed to the subdivision of the forest in multiple non-contiguous compartments. In the case of the present study, only forest compartments without logging activities and enrichment, were carefully selected and inventoried.

In rural area of Azaguié, many other small patches of forest exist. They are constantly penetrated by people for various reasons and had become therefore relatively poor in species that may interest them. Since 2002, the law N° 2002-102 of February 11th 2002 authorized the creation of Voluntary Natural Reserves through individual or community initiatives to protect priority forest patches. The private forest considered in this study is an example of these VNR then, in this forest any intervention of local people was prohibited since 2005. This VNR with 10 ha of area, was surrounded by many fallows and crops systems. Four CF fragments were also inventoried (Figure 1). In this area, these are the largest (2.5 to 6 ha) community forests and the closest to YPF. These forest were both very discountinuous and were secondary forests of 20 to 45 years old, which were considered by local farmers as "black forest" (old growth forest areas according to their perceptions). In these forests, the farmers' activities of harvesting non-timber forest products (NTFPs) were uncontrolled and difficult to measure.

In the study area, cocoa, cola, rubber and teak smallholder farming systems (of 1 to 30 years old) have traditionally prevailed. The management of shade or associated trees differed in these four crops systems. The cola and cocoa crops had two to thirty years old. Many cocoa and cola crops began by direct sowing of cocoa beans and cola nut after cutting forest. Some other farmers used seedlings from cocoa beans nurseries. At first ages, cocoa and cola were intercropped with several plant species such as avocado trees (*Persea americana*), orange trees (*Citurs* spp), bananas (*Musa* spp), yam (*Dioscorea* spp), and cassava (*Manihot esculenta*). But, peasants preferred, generally, to preserve or plant local species: fruit trees, medicinal species, food species and socio-cultural species. Decreasing tree crop yields in traditional coffee, banana and cola because of declining soil fertility, along with increased pest and disease pressure have led to the adoption of rubber and teak crops.

Teak and rubber crops were 10 years old, because of their recent introduction in the area. In the study areas, full sun crop systems concerned mainly teak and rubber. In these two crops, there are lower density of associated species (exotic and indigenous woody plants) than cocoa and cola crops. Indeed, these crops started by slash and burn system. In all these crops, cultivation techniques based on manual weeding and without herbicides impacted lianas, tree seedlings and herbaceous. All studied sites were located in the South, Southeast and Southwest of the YPF (Figure 1). Indeed, compared with other compartiments (Center and North) of this forest, the south stands out for its less logging activities and enrichment (Corthay, 1996).

Data collection

To identify a probable influence of the farming activities on forest trees species diversity, 70 plots (10 by habitat type) of 500 m^2 were sampled and inventoried in the YPF, the VNR, the CF, and farms (cocoa, cola, teak, rubber). This side of plot was adopted due to difficulties of having large integral patch in some farms and CF and the fact that it is better to have many little plots than few large ones to estimate biodiversity (Margurran, 2004). Morever, according to Chisholm et al. (2013), this size is similar to typical scale forest survey (0.04 ha). Plant species were surveyed using stratified sampling method. Each habitat type was considered as a stratum. For each habitat type, the 10 plots were randomly set up. In each of them, all trees with a dbh (diameter at breast high) greater or equal to 2.5 cm, were identified, measured, and counted. Only trees with dbh ≥ 2.5 cm have been included because trees of this size contribute more to the vast majority of plant diversity (Vroh et al., 2010). Tchouto (2004) and Adou Yao (2005), have shown that forest diversity based only on trees individuals with dbh ≥ 10 cm do not reflect more than 50% of all the diversity of a given area. The dbh ≥ 2.5 cm has then been taken in the objective to take into account the maximum species and individuals. Identification of species was made on field. Undetermined specimens (less than 2%) were identified by Laurent Aké-Assi and by comparison to those of the National Herbarium of Côte d'Ivoire (*Herbarium ivorensis* UCJ).

Data analysis

Data were analyzed using the package Biodiversity R developed by Kindt and Coe (2005). Species Accumulation Curve (SAC) was firstly used considering the « random » method, which adds sites at random order with 100 permutations. « Random » is the classic method which finds the mean SAC and its standard deviation from random permutations of the data (Gotelli and Colwell, 2001). SAC shows the trend in which additional species are encountered when a larger area is sampled. It allowed comparing diversity properties of community data sets.

Secondly, many diversity indices were calculated to compare trees species diversity between the habitats types: Species richness, Shannon, Pielou's evenness, Simpson. Species richness is the total number of species recorded during the botanical inventories. Estimation of total species richness for the survey area was calculated: bootstrap estimation, first-order Jackknife (Jack 1 estimation), and chao 1 estimation (Kindt and Coe, 2005).

Shannon index (H') is usually used in ecological studies as measure of heterogeneity taking into account the regularity of species abundance (Peet, 1974). This index was calculated by the following formula:

$$H' = -\sum_1^s (ni/N)\ln(ni/N) \quad (1)$$

In this formula, *ni* is individual number for species i, *N* is the total number of all species, and ln the logarithm at base "e" (Kent and Cooker, 1992). This index caculated with *ln* is usually between 1.5 and 4.0 and rarely surpasses 5.

Simpson diversity index (*D*') is the measure of the probability that two chosen individuals belong to two different species. *D*' is calculated according to the formula:

$$D' = \sum \frac{ni\ (ni-1)}{N\ (N-1)} \quad (2)$$

In the formula of *D*', *ni* is the number of individuals of specie "i", and *N* the total number of individuals. The Simpson diversity index D' ranks from 0 (low diversity) to 1 (high diversity).

Pielou's evenness (*E*) is the ratio of the Shannon diversity index over the maximum diversity (Kent and Cooker, 1992) and is calculated as follows:

$$E = \frac{H'}{lnS} \quad (3)$$

In the formula of *E*, *S* is the total number of species.

Thirdly, considering the fact that since a single diversity index will not provide sufficient information (Morris et al., 2014), the Renyi diversity profile was used. This diversity profile is one of the techniques for diversity ordering that were specifically designed to rank communities from low to high diversity (Kindt et al., 2006). Renyi diversity profile values (*Hα*) are calculated from the frequencies of each component species and a scale parameter α ranging from zero to infinity (Legendre and Legendre, 1998). The formula used to calculate *Hα* is:

$$H\alpha = \frac{\ln \sum (pi)\alpha}{1-\alpha} \quad (4)$$

In this formula, *pi* is the abundance of species i and α is a scale parameter.

Magurran (1988), Legendre and Legendre (1998), and Shaw (2003) have demonstrated that values of the Renyi profile at the respective scales of 0, 1, 2 and ∞ are related to species richness S, the Shannon diversity index *H*', the Simpson diversity index and the Berger–Parker diversity index. The Berger-Parker index of dominance is the proportion of the most common (abundant) species in the community or sample and the inverse of this index is used as an index of diversity : increasing the inverse of Berger-Parker index means increasing diversity and then the reduction in dominance of one species (Berger and Parker, 1970).

Considering the comparaison based on the Renyi diversity profil, community A is more diverse than a community B if the diversity profile for community A is everywhere above the diversity profile for community B (Kindt et al., 2006). Communities that have intersecting profiles cannot be ordered in diversity. In other words, Renyi diversity ordering is a graphical method of diversity ranking that allows distinguishing between situations where ecological communities (such as habitat types in this survey) can be ranked in diversity or situations where this is not conceptually possible (Magurran, 1988; Purvis and Hector, 2000).

Finally, a Principal Component Analysis (PCA) was performed to assess trees beta diversity, comparing the habitats based on the abundance of all species. Then, a smaller number of habitat groups was obtained on the basis of the percentage of contribution delivered by each species. Using the axes score abtained from PCA we performed cluster analysis in order to group habitats types taking into consideration the similarity between them. In other words, habitat with more similar floristic composition will tend to belong to the same group.

Table 1. Characteristics of the flora from different study sites in Azaguié area.

Sites	Origine of the species		Diversity index			
	Exotics (%)	Natives (%)	Richness	Shannon	Simpson	Evenness
YPF	0.01	99.99	85	3.69	0.96	0.83
VNR	0.01	99.99	67	3.01	0.91	0.72
CF	0.04	99.96	53	3.22	0.93	0.81
Cocoa	57.9	42.2	19	2.63	0.90	0.89
Cola	63.3	36.7	30	2.98	0.93	0.88
Rubber	0.2	99.8	5	1.43	0.73	0.89
Teak	28.6	71.4	7	1.37	0.63	0.71

YPF = Yapo Protected Forest, VNR = Natural Voluntary Reserve, CF = Community Forests.

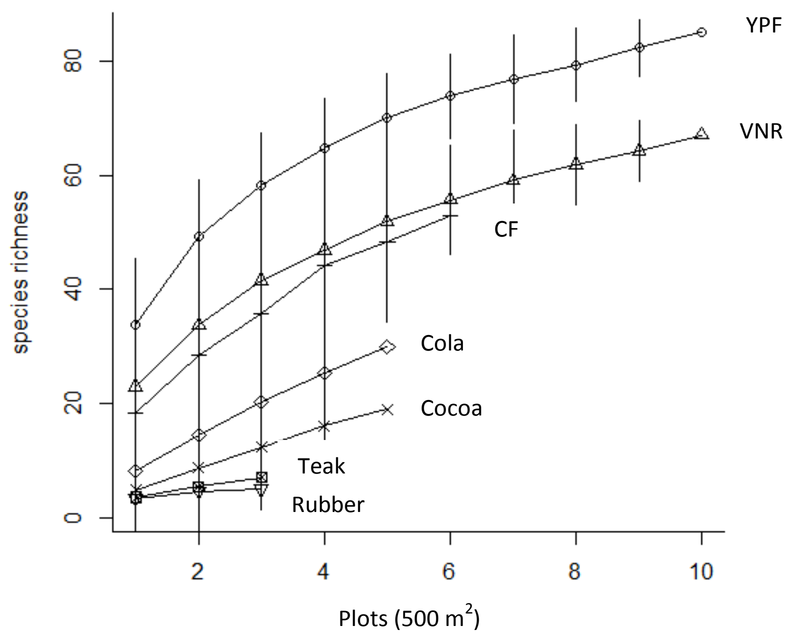

Figure 2. Species accumulation curves per habitat types. YPF = Yapo Protected Forest, VNR = Natural Voluntary Reserve, CF = Community Forests.

RESULTS

A total of 2588 stems belonging to 154 tree species with diameter ≥ 2.5 cm were recorded in all the habitat types. They were 1016 (39.3%) in the VNR forest, 950 (36.7%) stems in YPF, 432 (16.7%) stems in CF, and 190 (7.3%) stems in cocoa, cola, teak and rubber farms. The everage number of exotic trees species per farm types was 37.5% (ranging 0.2 to 57.9%) and 0.02% (ranging 0.01 to 0.04) for old forest types.

The species richness ranking from 85 in YPF to 5 in rubber farms (Table 1). Estimation of total species richness for the survey area ranged from 177.0 (bootstrap estimation) to 208 species (jackknife 1 estimation), and 263.3 (chao 1 estimation). The total value of Shannon index is 3.95 and ranking from 3.69 in YPF to 1.37 in teak farms. The corresponding Eveness index in all habitat types was 0.78. The lower values of Eveness (0.71 and 0.72) were obtained in teak farm and VNR forest. The higher values (0.88 and 0.89) were obtained in rubber and and cocoa farms.

Species accumulation curves (SAC) constructed separately for each habitat type showed that perennial crops farms were characterized by the lowest overall species richness (Figure 2). Furthermore, SAC showed that total species richness is the largest in the protected forests (VNR and YPF), and in the CF. The SAC indicated that we have not enough sample size for analyzing the ecological attributes of each habitat in the study area.

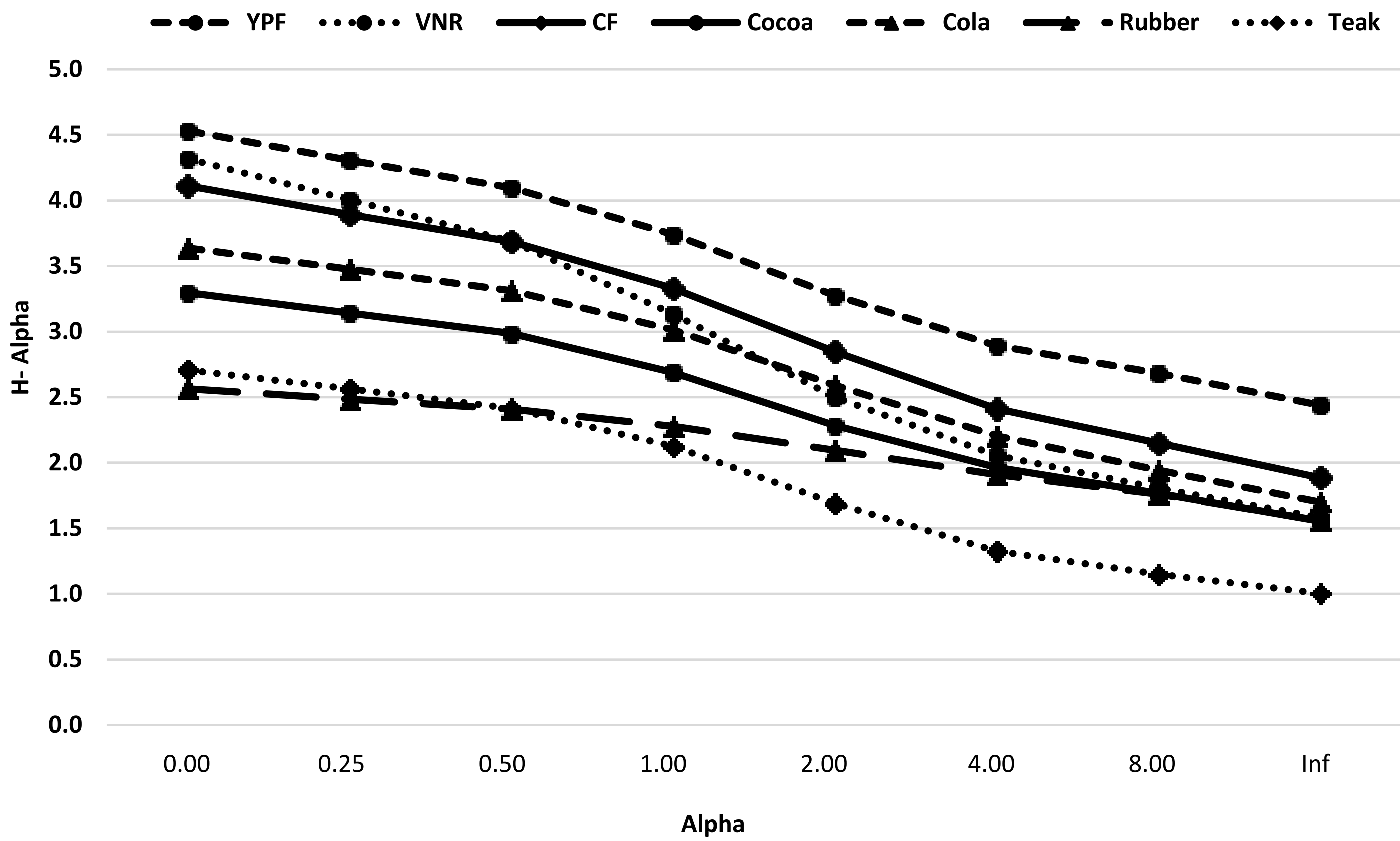

Figure 3. Comparison of diversity profile for the habitat types. YPF = Yapo Protected Forest, VNR = Natural Voluntary Reserve, CF = Communitu Forests.

Trees species diversity profiles in the different habitat types

The diversity profiles of each habitat type are represented in Figure 3. Results are based on 100 randomisations. The profile of YPF was consistently higher than other habitats for all values of alpha. The values of species richness at H (α = 0) were cleary different except those between rubber and teak farms which were still rather tight. The curves became more tight for Shannon diversity Index at H (α = 1) between VNR, CF and cola farms. Also, still rather tight curves was obtained between rubber and teak farms. For Simpson diversity index at H (α = 2), CF were higher than VNR and cola farms which stay tight. Also, rubber and cocoa farms are not distinguished and teak farm had the lower curve. Finally, results from the comparaison based on the diversity profile, showed that all habitat types have a clear bend towards low values of H-alpha at higher scales of alpha. The YPF was more diverse than the other habitats. But VNR, CF and cola-cocoa-rubber farms have intersecting profiles (at $\alpha = \infty$) and cannot be ordered in diversity. Teak and rubber farms had rather similar values for species richness at H (α = 0) and Shannon Index at H (α = 1), but they spread at higher scales of alpha.

Differences in species abundances and composition

A direct comparison of the habitat types showed that most species have low abundances (Figure 4). The forest habitats (YPF, VNR and CF) had the longer curves and the highest abundance values, whereas the shorter and steeper curves come from the farms.

In YPF, *Tarrietia utilis* (Sprague) Sprague was ranked 1 as this species had the largest total abundance of 98. This species was followed by *Carapa procera* DC. (90 stems) and *Baphia nitida* Lodd. (68 stems). The other species in this forest have relatively low total abundance. In the VNR forest *Dacryodes klainena* (Pierre) H.J. Lam was ranked 1 with the largest total abundance (246 stems) followed by *B. nitida* (175 stems) and *Tarrietia utilis* (137 stems). In CF *Futumia elastica* with a total number of abundance of 80 was ranked 1. This species was followed by *Anthocleista nobilis* G. Don (47 stems) and *Macaranga hurifolia* Beille (28 stems). In the cola, cocoa, rubber and teak farms, the most common abundance species were *Cecropia peltata* (cocoa, rubber and teak famrs), *Xylopia aethiopica* (Duna) A. Rich. (Cola, rubber and teak farms) and *F. elastica* (P. Preuss) Stapf (cocoa and cola farms). These species are completed by *Malus domestica* Borkh in cocoa farm,

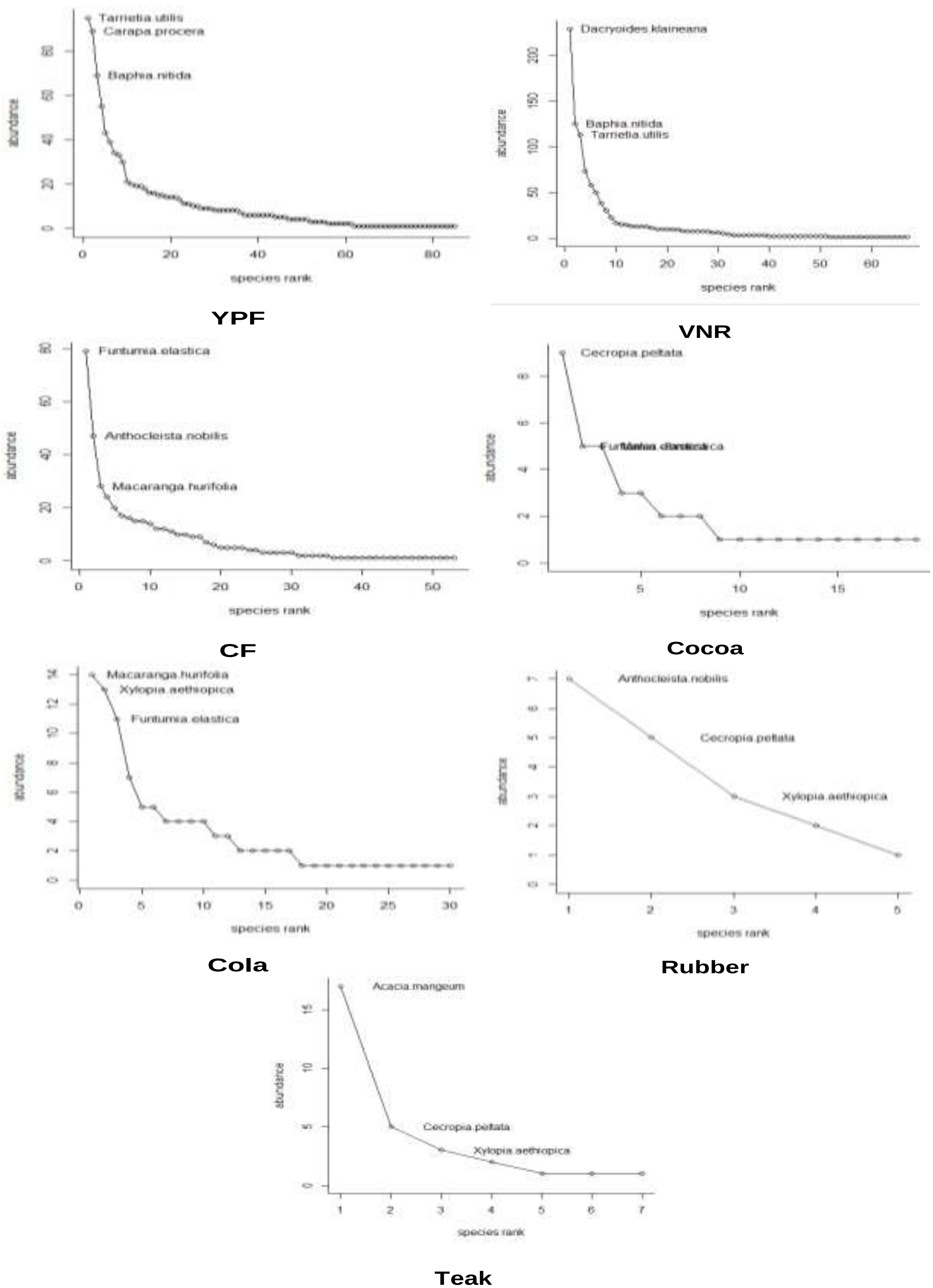

Figure 4. Tree species abundance curve with the names of 3 most abundant species per habitat type. YPF = Yapo Protected Forest, NVR = Natural Voluntary Reserve, CF = Community Forests.

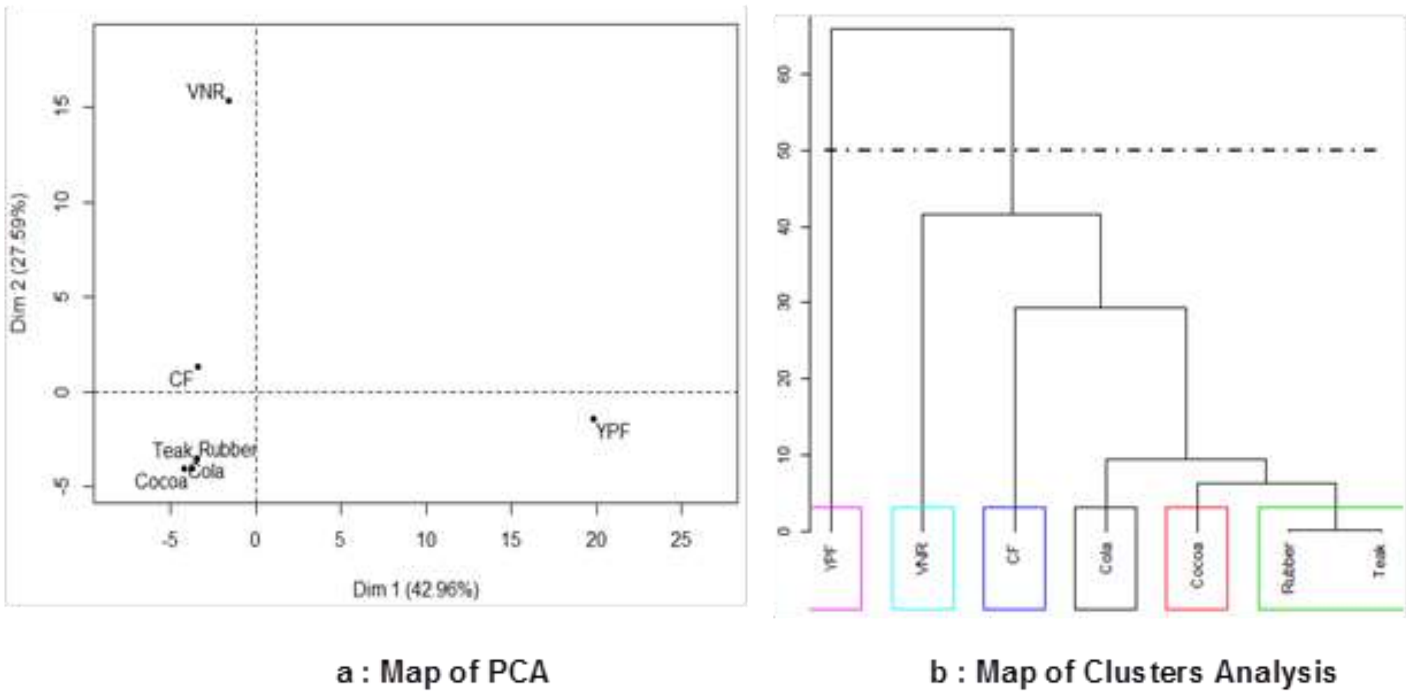

Figure 5. Ecologycal distance between habitat types based on species abundances. YPF = Yapo Protected Forest, VNR = Voluntary Natural Reserve, CF = Community Forests.

Acacia mangeum Willd. in teak, *M. hurifolia* in cola farm or *Anthocleista nobilis* in rubber farm.

Based on the difference in species composition, maps of PCA and Cluster Analysis (Figure 5a and b) showed two groups of habitat types. This separation was done considering 50% of species similarity between habitat types. Based on this score (50%), the first group is made of only the YPF which had few spcies in common with the others habitats types. In the second group, cocoa, cola, rubber and teak farms shared most of their species than forest (VNR and CF). Also, the CF shared most species with both farms and VNR forest.

DISCUSSION

Tree cover transitions can be evaluated on the basis of tree species diversity. The transition typically starts with a gradual change in diversity of spontaneously established trees on farms after deforestation, which is often followed by recovery of tree diversity through agroforestation (Ordonez et al., 2014). This hypothesis has been tested during this study based on different perennial crops.

The results of the present study showed that tree density decreases from forests (YPF, VNR and CF) to farms (cocoa, cola, rubber and teak) with a loss of more than 90% of stems. The decline of the density in the farms is irrevocably attributable to the interventions of the farmers. However, do these interventions always have negative effects on tree species diversity? One of the consequences is the higher number of exotic species in the farms compared to forest habitats. This fact also shows that the studied forests are old and more stable. The exotic species were very few in rubber farm, which means that in this perennial crop type, the farmers associated fewer exotic species than cocoa, cola and teak farms. Trees management practices in rubber farms were so different to those in cocoa agroforests where exotic species are usually associated for various roles in the pharmacopoeia and rural food security (Rice and Greenberg, 2000; Sonwa et al., 2007; Adou Yao et al., 2015, 2016; Cissé et al., 2016). However, the shape of the species accumulation curve indicated that more species (exotic and indigenous) would be expected if a larger number of farms were visited.

The results showed, also, that in YPF, the tree diversity profile was clearly dinstinct (larger) than those found in other habitat types. This situation can be general in tropical area. Indeed, during their researches which examined 138 scientific studies across 28 tropical countries, Gibson et al. (2011) found consistently that biodiversity level were substantially lower in farms and disturbed forests, and these authors concluded that old forests are irreplaceable for sustaining tropical biodiversity in the tropic. In other words, old growth rainforests such as YPF should be a top conservation priority and all major forms of disturbances (such as farms landscape : cocoa, cola, teak and rubber farms) invariably reduce biodiversity in tropical forests. Teak farm can however be distinguished clearly with lower diversity. Then, human disturbances show a more significant influence on plant diversity and are closely related to cultivation types as demonstrated by Li (2010). The study has demonstrated that VNR, CF and cola-cocoa-rubber farms have intersection profiles (at $\alpha = \infty$), and have the same trees diversity level. The many intersections show the complex pattern where many habitat types that are richer also have a less even species distribution (Kindt and Coe, 2005). It is therefore impossible to rank most VNR, CF and farms (cola, cocoa, rubber) in terms of diversity considering only the most abundant tree species. The lower Berger-Parker index of dominance at H ($\alpha = \infty$) showed a decreasing diversity and then the increase in dominance of one to three species (Berger and Parker, 1970). What are these species in the different study habitat types?

The species rank abundance curves have shown that most species have low abundances. In the YPF, the most abundance species were *T. utilis*, *C. procera,* and *B. nitida*. *T. utilis* and *B. nitida* were also most abundant in VNR with *D. klaineana*. Many other tree species were uncommon or rare in this protected forests. As in most tropical rainforests, both forest types had high proportion of rare species represented by a single occurrence. This observation is regular in other Ivorian protected forests such as Taï National Park (Scouppe, 2011). The same findings have been made in Paracou (Guyane) and Uppangala forest (Indian) by Collinet (1997) and Pascal and Pelissier (1996).

In the YPF area, the abundance of *T. utilis* had been demontrated by Corthay (1996) and Vroh et al. (2010, 2015b). The gregarious behavior of *T. utilis* mentioned by Aké-Assi (2002) in the study area could be one of the reasons that explains this observation. According to Salennave (1961) and Martinot-Lagarde (1961), Azaguié area is a natural habitat where this species grows. In CF and farms, *T. utilis* was absent because these habitat types were younger than YPF and the VNR (more than 60 years old (Vroh et al., 2015b). In these secondary forests that are less than 40 years old, as mentioned by Khan (1982), individuals of *T. utilis* were very rare.

D. klaineana has already been reported as an abundance species in YPF area (Bernhardt-Reversat et al., 1978). The higher abundance of pioneer species such as *F. elastica, M. hurifolia,* and *A. nobilis* mainly in CF could be linked to the disturbances effect in this habitat type. Indeed, CF are very exploited and infiltrated by villagers for non timber forest products harvesting. These interventions can contribute to the establishment of typical pioneer and light demanding species (Alexandre, 1982) linked to their heliophilic character (Van Steenis, 1958).

In the farms, these same pioneer species are also abundant, with some exotic species (*A. mangium* and *M. domestica*) or native species which more interest the farmers (*X. aethiopica*). Furthermore, in the farms, some species such as *F. elastica* and *M. hurifolia* are all remnant trees from CF. These species are selected by farmers due to their low interference with perennial crops (cocoa and cola farms). Then, in farms, there are various tree species also abundant in CF, but in very different proportions. This is a consequence of farmer's activities. For Boffa et al. (2008), farmers do not manage species, but individual trees or populations of trees. In YPF area, farmers' management techniques includes, declining trees diversity and increasing the evenness in the farms (ranging from 0.88 to 0.89) except for teak farm.

Conclusion

This study was based on a meta-analysis to evaluate tree species diversity in four perennial crop farms (cocoa, cola, rubber and teak) in the southeast of Côte d'Ivoire. Not surprisingly, tree diversity profile was significantly lower in farms landscape and less protected forests. Undisturbed tropical forests such as YPF according to this study, are truly unique bastions of tree diversity and this paper suggest that they must be preserved at all costs to provide refuge to the millions of species. There are usually limited funds available for conservation efforts, and the forest authorities must choose carefully where to focus these efforts. One clear priority emerge from this paper : the preservation of intact old tropical forests. In farming systems, the representation of many species with only few individuals points out their low density and isolation. However, the results indicate that a substantial number of tree species can be found on farms, of which most are exotic. Also, when we have taken into account the abundance of species, many trees turn out to be indigenous in these farms. This pattern indicates that a larger proportion of indigenous species are present in farms. Finally, that is an advantage to have lower alpha diversity in farms but a high beta diversity between the habitat types in the study area. This fact can increase the gama diversity for the area. What are the drivers of these results in the study area? Further researchs are required to determine if these differences reflect higher levels of natural regeneration of indigenous species or if these species were planted in the farms.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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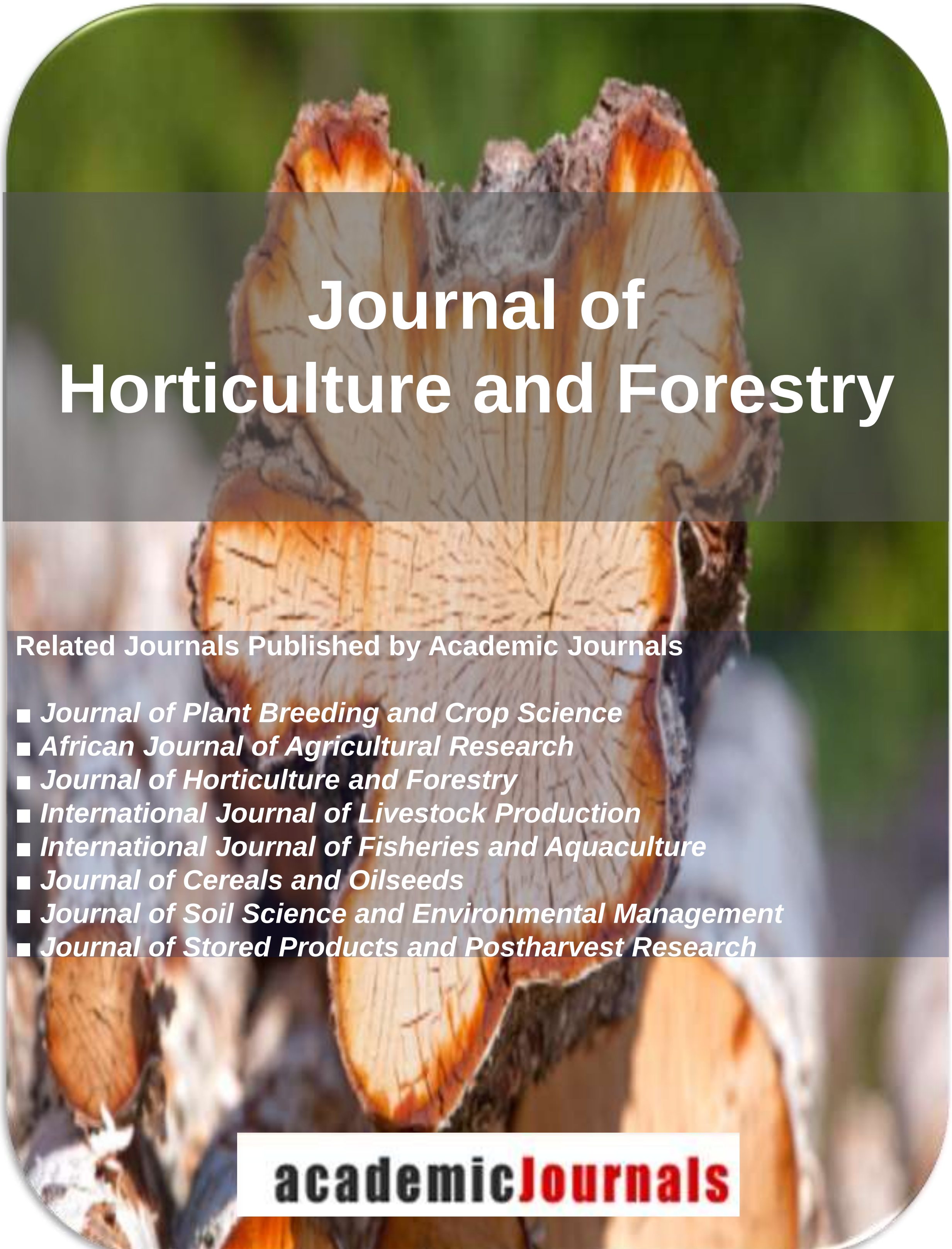

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