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Woodland fragmentation explains tree species diversity in an agricultural landscape of Southern Africa

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Abstract: Adopting theoretical frameworks that seek to understand biodiversity variations in agricultural landscapes is important for biodiversity-agriculture coexistence. In this study, we statistically tested whether the area-diversity relationship predicted by the island biogeography theory can successfully be used to explain differences in tree species diversity among different woodland patch sizes in Nyabamba resettlement area of south-eastern Zimbabwe. We used IKONOS imagery of 2009 to classify woodland, plantation and cropland areas, and GIS to calculate the woodland patch sizes. Tree species diversity was calculated from field data and then quantified using Simpson's (1-D) index. One Way ANOVA and Post Hoc analysis were used to test whether woodland patches of different sizes (less than 4 ha, between 4-25 ha and greater than 25 ha) had significant differences in mean tree species diversity. Our results show that larger patches had significantly ($P < 0.05$) higher mean species diversity than smaller woodland patches. The results indicate that the island biogeography theory can be used to explain tree species diversity differences in an agriculturally fragmented woodland.

Resumen: La adopción de marcos teóricos que busquen comprender las variaciones de la biodiversidad en paisajes agrícolas es importante para la convivencia entre la agricultura y la diversidad biológica. En este estudio probamos estadísticamente si la relación área-diversidad predicha por la teoría de biogeografía de islas se puede utilizar con éxito para explicar las diferencias en la diversidad de especies arbóreas entre parches de bosque abierto de diferentes tamaños en la zona de reasentamiento Nyabambaen el sureste de Zimbabue. Utilizamos imágenes IKONOS de 2009 para clasificar a las áreas de bosque abierto, plantaciones y tierras de cultivo, y el cálculode los tamaños de los parches de bosque abierto se hizo por medio de SIG. La diversidad de especies arbóreas se calculó a partir de datos de campo y se cuantificó mediante el índice de Simpson (1-D). Se utilizaron un Análisis de Varianza de una Vía y un análisis post hoc para probar si la diversidad promedio de especies arbóreas difería significativamente entre los parches de bosque abierto de diferentes tamaños (menos de 4 ha, entre 4-25 ha y más de 25 ha).Nuestros resultados muestran que los parches de bosque abierto más grandes tuvieron una diversidad promedio de especies significativamente mayor ($P < 0.05$) que los parches pequeños. Se puede utilizar la teoría de biogeografía de islas para explicar las diferencias enla diversidad de especies arbóreas en los bosques abiertos fragmentados por la agricultura.

Resumo: A adopção de referenciais teóricos que procuram compreender as variações da biodiversidade em paisagens agrícolas é importante para a coexistência da biodiversidade

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agrícola. Neste estudo testámos, estatisticamente, se a relação área-diversidade predita pela teoria da biogeografia de ilha poderia ser usada com êxito para explicar as diferenças na diversidade arbórea específica entre os diferentes tamanhos de manchas de mata na área de reassentamento em Nyabambano sudeste Zimbabwe. Usámos imagens IKONOS de 2009 para classificar a mata, a plantação e as áreas de terras cultivadas, e GIS para calcular os tamanhos das manchas de mata. A diversidade das espécies arbóreas foi calculada a partir de dados de campo e, em seguida, quantificada através do índice de Simpson (1-D). Uma análise de variância simplese Post-Hoc, foi usada para testar se as manchas de mata de tamanhos diferentes (menos de 4 ha, entre 4-25 ha e maior que 25 ha) apresentavam diferenças significativas nadiversidade média de espécies arbóreas. O nossos resultados mostraram que manchas maiores apresentavam significativamente maior diversidade média de espécies ($P <$ 0,05) do que as manchas menores de mata. Os resultados indicam que a teoria da biogeografia de ilha pode ser usada para explicar as diferenças de diversidade de espécies de árvores numa mataagricolamente fragmentada.

Key words: Area-diversity, island biogeography theory, patch size, species diversity.

Introduction

Habitat fragmentation is one of the main threats to biodiversity (CBD-Secretariat 2001). The threat results from the progressive sub-division of species habitats into smaller, geometrically more complex and isolated patches (Harris & Weiner 2003), mainly due to agricultural intensification (Grashof-Bokdam 1997; Tynsong & Tiwari 2011). Habitat fragmentation ultimately results in habitat patches that can only support a small number of species that become increasingly prone to extinction due to crowding effects and increased resource competition (Hobbs & Yates 2003; Laurance *et al.* 2002; Stevenson & Aldana 2008; Young *et al.* 1996). In this regard, patch size becomes a major explanatory factor for species diversity. Thus, the promotion of biodiversity friendly agricultural practices should probably take patch size of remnant natural habitats into consideration at the design stage.

The theory of island biogeography (MacArthur & Wilson 1967) has offered a simple mechanism which scientists use to explain species diversity as a function of patch size and isolation (Forman & Godron 1986). Specifically, within this framework patch size is the primary determinant of species diversity where larger patches are predicted to have more habitats which, therefore, support more species (Forman & Godron 1986; Whitcomb *et al.* 1981; Whittaker & Fernandez-Palacious 2007). However, most studies on the effects of habitat fragmentation and area-diversity relationships have mainly focused on migratory species such as birds (Lampila *et al.* 2005; Ruiz-Gutierrez *et al.* 2010; Vergara & Armesto 2009) and insects (Braschler *et al.* 2009; Browers & Newton 2009; Ducheyne *et al.* 2009; Ockinger *et al.* 2009). This is not surprising since the island biogeography theory was developed with migratory species as the target.

Sedentary species such as tree species have received limited attention within the context of the island biogeography theory. Only recently, attention has begun to focus on sedentary species (Echeverria *et al.* 2007; Hill & Curran 2003; Raghubanshi & Tripathi 2009) due to the realisation that although the island biogeography theory was formulated with migratory species in mind, the theory could provide a useful framework for the analysis of the effects of habitat fragmentation on biodiversity especially in agricultural landscapes. Analysis of sedentary species diversity in agricultural landscapes as a function of patch size is especially important for purposes of determining the optimal patch size useful to conserve biodiversity within these disturbed landscapes. For example, it is important to know whether there is an optimal remnant woodland patch size in which landscape-representative diversity can be conserved. Therefore, testing hypotheses within the framework of the island biogeography theory on sedentary species such as tree species in agricultural landscapes is critical for balancing both conservation and agricultural production objectives.

The development of satellite remote sensing particularly the recent deployment of operational high spatial resolution satellites such as QuickBird and IKONOS has resulted in improved opportunities to test the island biogeography theory in agriculturally fragmented landscapes. High spatial resolution satellite imagery, with 2-5 m pixel size offers potential for mapping vegetation diversity and distributions (Nagendra *et al.* 2010; Roy *et al.* 2012). Satellite data has advantages over a variety of field based methods because of its ability to cover large spatial extents with enhanced spatial and temporal detail (Kerr & Ostrovsky 2003). Thus, remote sensing offers scientists an opportunity to study complex ecological dynamics in a systematic, repeatable and spatially exhaustive manner over broad areas (Duro *et al.* 2007; Nagendra *et al.* 2010). To this end, the use of high spatial resolution imagery may improve our understanding of the effects of habitat fragmentation at a landscape scale.

In this study, we tested the extent to which the island biogeography theory can be used to explain tree species diversity as a function of woodland patch size in a recently settled agriculturally fragmented landscape of Nyabamba A1 resettlement area in south-eastern Zimbabwe. The island biogeography theory predicts that larger islands (patches) contain higher diversity than smaller islands (patches). Thus, we hypothesised that larger woodland patches would have higher tree species diversity compared with smaller woodland patches in the study area. We mapped woodland patches from high spatial resolution IKONOS satellite data of 6 March 2009 and calculated tree species diversity from field sampled data.

Materials and methods

Study area

The study was conducted in Nyabamba A1 resettlement area of Chimanimani district in the south-eastern part of Zimbabwe, located between 19° 59' and 20° 00' South and 32° 49' and 32° 50' East on an area covering 747,7 ha. Fig. 1 indicates the study area. In Zimbabwe, the A1 resettlement model is a communally owned type of settlement meant to extend and improve the base for productive agriculture in the small holder farming sector as well as eliminate squatting and other disorderly settlements in both urban and rural landscapes (Ministry of Lands 2007). Zimbabwe is classified into five agro ecological regions based on capacity to support agriculture (Vincent & Thomas 1962). The study area is located in agro-ecological region one of Zimbabwe with an average mean annual rainfall of 1000 mm (Vincent & Thomas 1962). The climate is strongly seasonal being characterized by a dry season spanning from May to September and a short wet season from October to April. The average mean annual temperature of the area is between 17 and 21°C (Jones & Harris 2008) and the area lies at an elevation of about 1600 - 1800 m above mean sea level. The soils of the area are predominantly orthoferallitic soils parti-cularly Rhodic and Haplic Ferralsols (FAO-UNESCO 1988). The natural land cover in the area is wet miombo, characterized by small fragments of *Parinari curatellifolia*, *Erythrina abssinica* and *Ficus sycomorus* that are now confined to a few remnant woodland patches surrounded by an agriculturally dominated mosaic. Small patches of exotic tree species such as *Acacia dealbata, Eucalyptus* spp. and *Pinus* spp. also exist in the area. Human settlement in Nyabamba dates back to 2000 when agrarian reforms were initiated in the area. Land use is characterized by use of individually owned plots. The major land use activity in Nyabamba is rain fed maize (*Zea mays)* production. At present, clearance for agricultural purposes and logging for fuel wood are some of the underlying causes of habitat fragmentation in the study area.

Sampling and tree species data collection

Prior to tree species diversity assessment in the field, we classified an IKONOS satellite image (www.geoeye.com) for the study area using the maximum likelihood classifier. The image had a spatial resolution of 4 m and was acquired on the 6th of March 2009. Three land cover types resulted from classification namely cropland (predominantly grown with maize (*Zea mays)*), plantation (dominated by *Acacia dealbata, Eucalyptus* spp. and *Pinus* spp.) and woodland (Fig. 2).

Post classification accuracy was carried out using sixty independent ground control points and yielded 76 % accuracy based on the Kappa statistic. Class spectral separability was analysed using the Jeffries-Matusita separability measure where values that are less than 1.9 are considered not separable and separable otherwise. All comparisons yielded values greater than 1.9 indicating that the land cover types have good separability (woodland and plantation 1.98; woodland and cropland yielded 1.99 while plantation and crop-

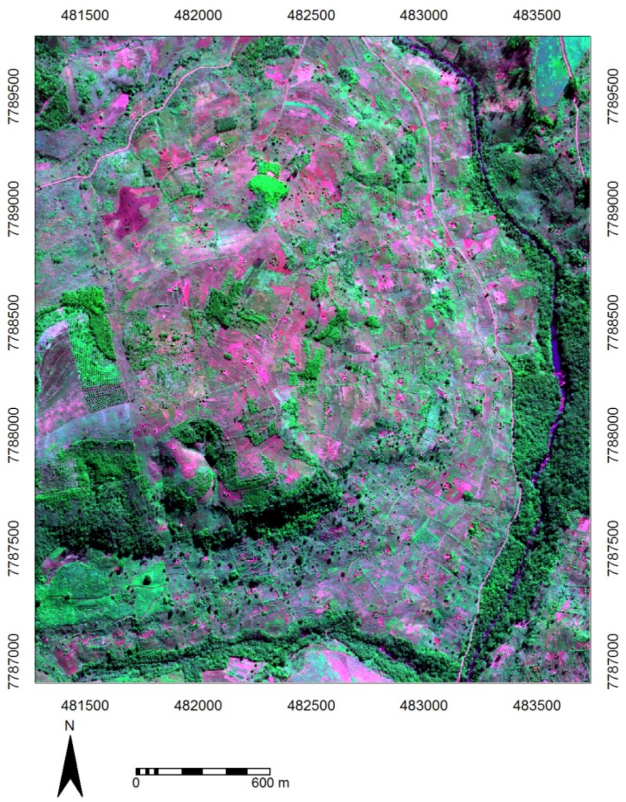

Fig. 1. Study area. Map coordinates are in WGS84 UTM Zone 36 South.

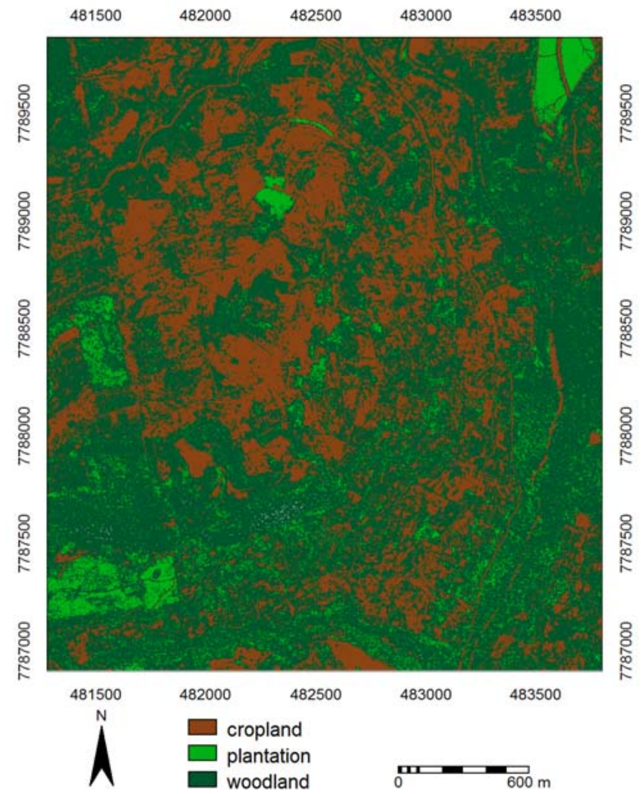

Fig. 2. The different land cover classes in the study area.

land had a measure of 1.99). We then extracted woodland patches using a logical operator in ILWIS GIS and then performed post-classification smoothing using a 9 by 9 pixel filter to enhance the image and avoid having a large number of small woodland patches of sizes less than 0.0144 hectares. Based on the resultant woodland map, we used stratified random sampling to generate thirty random sampling points distributed equally across the sampling strata for purposes of detailed field based measurement of tree species diversity (Fig. 3). Under this sampling strategy ten (10) plots were selected in each of the patch size categories and were located at the edge of the patch as well as in the interior.

We entered the thirty sampling points into a handheld Global Positioning System (GPS unit) as way points for fieldwork carried out in June 2010. The GPS was used to navigate to each of the sampling points. In each case the generated sample point became the centre of a 15 by 15 metre sampling plot. Within the strata, data on tree species composition and frequency of occurrence were measured in the sampling plot. The 15 m plot size was adapted from previous tree diversity surveys that used plot sizes ranging from 25 to 400 m^2 and at times, as large as 25 000 m^2 for trees in large woods and forests (Echeverria *et al.* 2007; Mutowo & Murwira 2012; Sutherland 1996). All tree species with a height $\geq$ 1.3 m located within the plot were sampled and data recorded. The threshold of greater or equal to 1.3 m on tree sampling was used in order to eliminate tree saplings and is also in line with FAO guidelines of measuring tree diameter (dbh) at 1.3 m breast height above the ground since dbh was also collected in the field for later use (FAO 2004). Identification of tree species that we failed to identify in the field was carried out by a qualified botanist at the National herbarium and botanical gardens in Harare using voucher samples collected during fieldwork.

Tree species diversity assessment

The Simpson 1-D (Simpson 1949) was used to characterize tree species diversity. The index is a measure that accounts for both richness and proportion (percent) of each species and takes the form

$$1 - D = 1 - \sum pi^2 \tag{1}$$

where, *pi* is the proportion of the i[th] species in the quadrat.

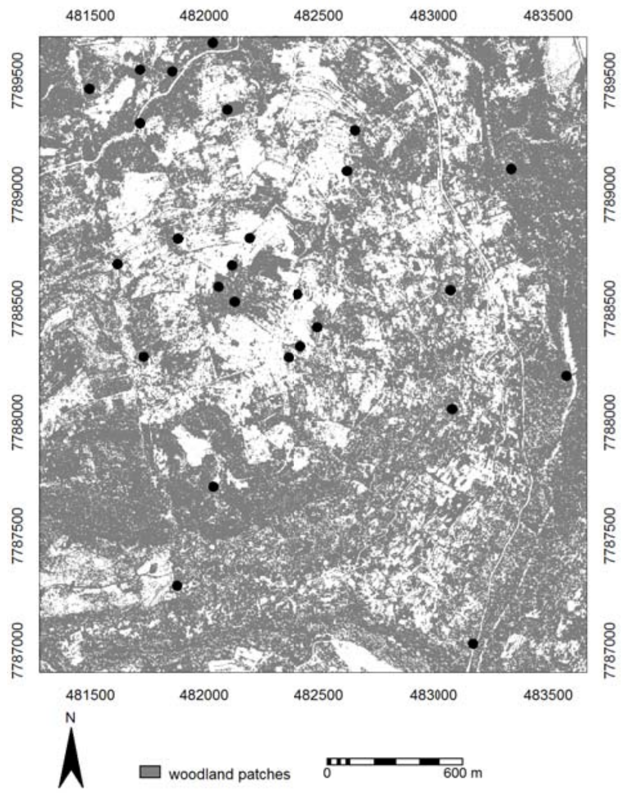

Fig. 3. Woodland patches and sampling points (black dots).

Explanatory Data Analysis (EDA) on area-diversity relationships was then carried out. We split the woodland patches using the area numbering algorithm and came up with size ranges. Tree species diversity data was plotted against the patch size and it assumed three distinct size categories i.e. below 4 hectares, between 4-25 hectares as well as above 25 hectares. These categories were then used to classify individual patches into three patch sizes for subsequent data analysis. This natural clustering of tree species diversity in different sizes was done so as to avoid arbitrary classification of size classes.

We tested the data for normality using the Komolgorov Sminorv test. Results of the normality test indicated that the data conform to a normal distribution curve ($P > 0.05$) thus parametric tests were used for subsequent data analysis. Specifically we used descriptive statistics, One Way Analysis of Variance (ANOVA) and Least Significant Difference (LSD) Post Hoc multiple comparisons to test for any significant differences in tree species diversity within as well as between the patch sizes.

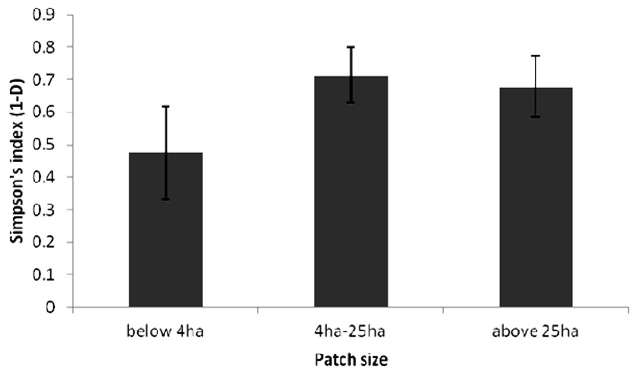

Fig. 4. Mean tree species diversity distribution in general. Whiskers show 95 % confidence interval.

Results

Land cover types in the study area

The proportion covered by each of the three land cover types in the study area is illustrated in Fig. 2. It can be observed that woodland is the major land cover type found in Nyabamba resettlement area. Woodlands cover 64 % (475.7 hectares), cropland 29 % (220.2 hectares) while plantation is 7 % (51.8 hectares) of the total area.

Tree species composition

Several indigenous and exotic tree species were observed in the study area with the indigenous species being the most dominant. Specifically, there were twenty-two indigineous tree species and seven exotic tree species (Table 1 and Table 2). The dominant tree species found in the area include *Acacia dealbata* (925), *Albizia adianthifolia* (76), *Annona senegalensis* (54*), Erythrina abssinica* (88), *Parinari curatellifolia* (59)*, Psidium guajava* (60) and *Trema orientalis* (59).

Tree species diversity as a function of patch size

Tree species diversity in the woodland patches found in the study area ranges from 0.47 to 0.71 (Simpson 1-D index) as illustrated in Fig. 4. Patches with sizes between 4-25 ha have relatively higher mean tree species diversity (0.71) compared with patches greater than 25 ha (0.68) and patches less than 4 ha (0.47).

It can be observed that tree species diversity differs significantly between the different patch size classes (ANOVA $F = 5.102$, $P = 0.014$). Specifically, there is a significant differences in mean tree species diversity between patches less than 4 ha and patches between 4-25 ha (Mean difference = 0.2387,

Table 1. A list of the tree species per patch size category. Numbers in brackets indicate the number of trees found.

Patches below 4 ha	Patches between 4-25 ha	Patches above 25 ha
Acacia dealbata (627)	*Acacia dealbata* (73)	*Acacia dealbata* (225)
Erythrina abssinica (63)	*Parinari curatellifolia* (35)	*Albizia adianthifolia* (64)
Trema orientalis (17)	*Trema orientalis* (31)	*Syzigium cordatum* (52)
Annona senegalensis (13)	*Psidium guajava* (22)	*Rhus chirindensis* (40)
Bridelia micrantha (6)	*Erythrina abssinica* (21)	*Psidium guajava* (37)
Persea americana (5)	*Brachystegia spiciformis* (20)	*Annona senegalensis* (30)
Cussonia kirkii (5)	*Rhus chirindensis* (15)	*Bridelia micrantha* (27)
Combretum apiculatum (1)	*Bridelia micrantha* (14)	*Parinari curatellifolia* (24)
	Ficus sycomorus (13)	*Pterocarpus angolensis* (13)
	Combretum apiculatum (13)	*Trema orientalis* (11)
	Macaranga capensis 12)	*Cussonia kirkii* (11)
	Uapaca kirkiana (11)	*Vangueria infausta* (10)
	Annona senegalensis (11)	*Macaranga capensis* (9)
	Mangifera indica (9)	*Burkea africana* (8)
	Persea americana (7)	*Mangifera indica* (7)
	Cussonia kirkii (7)	*Julbernadia globiflora* (7)
	Albizia adianthifolia (7)	*Ficus sycomorus* (6)
	Vangueria infausta (5)	*Combretum apiculatum* (5)
	Heteropyxis dehniae (3)	*Heteropyxis dehniae* (5)
	Anthocleista grandiflora (2)	*Eucalyptus spp* (4)
	Jacaranda mimosifolia (1)	*Erythrina abssinica* (4)
	Catha edulis (1)	*Anthocleista grandiflora* (3)
	Pinus spp (1)	*Brachystegia spiciformis* (1)
	Strychnos cocculoides (1)	

P = 0.007), as well as, between patches less than 4 ha and patches greater than 25 ha (Mean difference = -0.2033, P = 0.017). Furthermore, we also observe that tree species diversity does not differ significantly between patches whose size is between 4-25 ha and patches greater than 25 ha (Mean difference = -0.0354, P = 0.669).

Discussion

Results indicate that tree species diversity varies significantly between small and large woodland patches thereby confirming the area-diversity predictions of the island biogeography theory that high species diversity is associated with large patch sizes and low species diversity with small patches (MacArthur & Wilson 1967). Similar studies (Echeverria *et al.* 2007; Hill & Curran 2003; Lindborg *et al.* 2012; Raghubanshi & Tripathi 2009) found significant effects of patch size on tree species diversity. Larger woodland patches are able to support a greater number of individual tree species compared with smaller patches, and thus are also likely to have species with larger population sizes (Kisel *et al.* 2011). Conversely, species diversity in small patches is relatively low as small patches contain less habitats resulting in a small tree species populations that are prone to density-dependent stochastic extinction processes (Honnay *et al.* 1999). Thus, we deduce that our results are consistent with the area-diversity predictions of the island biogeography theory.

The result in this study that woodland patches larger than 4 ha had significantly higher tree species diversity than woodland patches of less than 4 ha suggests that leaving remnant woodland patches of greater than 4 ha in the landscape could improve chances of promoting agricultural

Table 2. Characteristics of all sampled plots.

Plot ID	Patch size (ha)	Number of species	Species
1	0.0244	1	*Acacia dealbata*
2	0.028	4	*Acacia dealbata, Bridelia micrantha, Erythrina abssinica Persea americana*
3	0.084	3	*Acacia dealbata, Bridelia micrantha, Erythrina abssinica*
4	0.1276	3	*Acacia dealbata, Annona senegalinsis, Erythrina abssinica*
5	0.132	1	*Cussonia kirkii*
6	0.618	3	*Acacia dealbata, Annona senegalinsis, Erythrina abssinica*
7	0.7472	6	*Acacia dealbata, Annona senegalinsis, Bridelia micrantha, Combretum apiculatum, Erythrina abssinica,, Trema orientalis*
8	1.1888	2	*Acacia dealbata, Trema orientalis*
9	3.3668	4	*Acacia dealbata, Erythrina abssinica, Persea americana, Trema orientalis*
10	3.7244	1	*Acacia dealbata*
11	6.698	9	*Acacia dealbata, Annona senegalinsis, Bridelia micrantha, Combretum apiculatum, Ficus sycomorus, Psidium guajava, Parinari curatellifolia, Trema orientalis, Vangueria infausta*
12	6.698	6	*Bridelia micrantha, Cussonia kirkii, Parinari curatellifolia, Pterocarpus angolensis, Syzigium cordatum, Vangueria infausta*
13	6.8908	7	*Albizia adianthifolia, Bridelia micrantha, Catha edulis, Cussonia kirkii, Ficus sycomorus, Psidium guajava, Trema orientalis*
14	7.1728	4	*Albizia adianthifolia, Bridelia micrantha, Combretum apiculatum, Ficus sycomorus*
15	22.3604	15	*Acacia dealbata, Albizia adianthifolia, Brachystegia spiciformis, Bridelia micrantha, Combretum apiculatum, Cussonia kirkii, Erythrina abssinica, Ficus sycomorus, Heteropyxis dehniae, Jacaranda mimosifolia, Pinus* spp, *Rhus chirindensis, Strychnos cocculoides, Uapaca kirtiana, Vangueria infausta*
16	22.3604	3	*Bridelia micrantha, Mangifera indica, Persea americana*
17	22.3604	4	*Acacia dealbata, Annona senegalinsis, Bridelia micrantha, Parinari curatellifolia*
18	22.3604	3	*Mangifera indica, Persea americana, Psidium guajava*
19	22.3604	3	*Anthocleista grandiflora, Combretum apiculatum, Mangifera indica*
20	22.3604	13	*Albizia adianthifolia, Annona senegalinsis, Bridelia micrantha, Burkea africana, Combretum apiculatum, Cussonia kirkii, Erythrina abssinica, Heteropyxis dehniae, Parinari curatellifolia, Pterocarpus angolensis, Rhus chirindensis, Syzigium cordatum, Trema orientalis*
21	152.226	9	*Acacia dealbata, Albizia adianthifolia, Annona senegalinsis, Bridelia micrantha, Combretum apiculatum, Parinari curatellifolia, Psidium guajava, Trema orientalis, Vangueria infausta*
22	152.226	6	*Bridelia micrantha, Heteropyxis dehniae, Psidium guajava, Rhus chirindensis, Syzigium cordatum, Vangueria infausta*
23	152.226	3	*Acacia dealbata, Psidium guajava, Trema orientalis*
24	152.226	4	*Acacia dealbata, Annona senegalinsis, Albizia adianthifolia, Bridelia micrantha*
25	272.054	5	*Annona senegalinsis, Burkea africana, Parinari curatellifolia, Rhus chirindensis, Vangueria infausta*
26	272.054	4	*Annona senegalinsis, Eucalyptus* spp, *Syzigium cordatum, Parinari curatellifolia*
27	272.054	1	*Acacia dealbata*
28	272.054	10	*Acacia dealbata, Albizia adianthifolia, Brachystegia spiciformis, Bridelia micrantha, Erythrina abssinica, Ficus sycomorus, Julbernadia globiflora, Parinari curatellifolia, Syzigium cordatum, Vangueria infausta*
29	272.054	3	*Anthocleista grandiflora, Combretum apiculatum, Mangifera indica*
30	272.054	6	*Albizia adianthifolia, Bridelia micrantha, Ficus sycomorus, Parinari curatellifolia, Psidium guajava, Trema orientalis*

production and biodiversity conservation in resettled landscapes. These results are consistent with the observations of Blann (2006) who found that remnant habitat patches are responsible for maintaining biodiversity currently present in agricultural landscapes. Thus, we make a claim that the maintenance of woodland patches at sizes greater than 4 ha could promote tree species diversity in agriculturally fragmented landscapes. However, we should caution that our study area is small, therefore, the results may be applicable to areas equal or less the same size as our study area (747,7 ha).

Results of accuracy assessment performed on the classified images indicate a relatively high level of classification accuracy as shown by a Kappa statistic of 76 %. In addition, the Jeffries-Matusita separability measure yielded values greater than 1.9 indicating that the land cover types have good separability (woodland and plantation 1.98; woodland and cropland yielded 1.99 while plantation and cropland had a measure of 1.99). Both measures of accuracy and spectral separability used in this study were high and thus considered appropriate for testing the island biogeography theory on patches of different sizes. Although, research has indicated that non-parametric classifiers such as neural network and decision tree classifier may provide better classification results than parametric classifiers (Huang & Lees 2004; Lu & Weng 2007), we used the maximum likelihood classifier because of its robustness and the availability of sufficient training data which improves the classification result. Furthermore, the fine spatial, spectral and radiometric resolution of the IKONOS image used in this study greatly reduces the mixed pixel problem, providing a greater potential to extract much more detailed information on land cover. In fact, Yang & Lo (2002) observe that as the spatial resolution of an image increases the number of mixed pixels decreases and spectral confusion is significantly reduced.

Where our study differs from previous studies (Braschler *et al.* 2009; Browers & Newton 2009; Collinge & Forman 1998; Ducheyne *et al.* 2009 ; Lampila *et al.* 2005; Ockinger *et al.* 2009; Ruiz-Gutierrez *et al.* 2010; Vergara & Armesto 2009) is in testing whether woodland fragments in an agriculturally fragmented landscape conform to the predictions of the island biogeography theory. While our findings may not be surprising, it is siginificant to note that studies that have successfully used the island biogeography theory to explain the impact of habitat fragmentation on biodiversity have mainly focused on migratory species and not sedentary ones such as trees. However, we have to caution that the results of this study are based on a study area of a smaller spatial extent (747,7 ha) and specific geographic location. Further studies may need to be conducted to find out if the island biogeography area-diversity prediction is applicable at large spatial extent and in different locations.

Conclusions

We statistically tested whether the area-diversity relationship predicted by the island biogeography theory can successfully be used to explain differences in tree species diversity among different woodland fragments in Nyabamba resettlement area of south-eastern Zimbabwe. We concluded that patch size variations explain tree species diversity in agriculturally fragmented woodlands. We further concluded that human driven forest fragmentation has a significant effect on tree species diversity. Finally, we concluded that although the island biogeography theory was developed for true oceanic islands, its predictions can be applied to agriculturally fragmented woodlands.

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