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Assessment of Natural Regeneration of Woody Vegetation in Zalingei Locality, Central Darfur State, Sudan

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ABSTRACT

This paper is part of a big research work on the analysis of woody vegetation and natural regeneration of some areas, as influenced by topography and distance from major wades at the study area. The systematic circular line-plot sampling design and systematic strip sampling after Wiley and Sons [1], was used for this survey. Using the Global Positioning System (GPS), measuring tape (100 m), a compass, four inventories were carried out in the two seasons of 2013 and 2014. To know the main source of seedlings (seeds or coppice or sprouts) the one sample case of the Chi- square Test was used. Regression analysis was used to find the relationship between mature trees and natural regeneration. The results indicated that the contemporary flood plain site have less seedlings compared to other sites. *Albizia anthelmintheca, Combertum glutinosum, Sclerocarya birrea, Anogeissus leiocarpus Acacia tortilis acacia polycantha, Faidherbia albida* have less survival rate. However, *Albizia amara, Balanites aegyptiaca, Acacia senegal, Dichrostachys cinerea, Acacia nilotica, Ziziphus spina-christi* have highly survival rate. Statistical analysis showed that there is highly significant difference between the three sources of seedlings (seeds, coppices and sprouts) for *Albizia amara, Balanites aegyptiaca and Dichrostachys cinerea. Albizia amara, Balanites aegyptiaca* were the main source of seeds followed by coppice and then sprouts, but Dichrostachys cinerea was the main source of seeds followed by coppice and sprouts In general there was strongly positive and highly significant differences between mature trees and seedlings at $P \leq 0.001$ and $P \leq 0.01$ and there is significant differences between mature trees and seedlings at $P \leq 0.05$ for all trees in various sites except *Faidherbia albida* at lower terraces in Abata , *Ziziphus abyssinica* at lower terraces in Zalingei and *Acacia girrardii* at clay plain Abata.

Introduction

Natural regeneration is the process by which old trees and shrubs replace themselves without human intervention [2]. It usually refers to the process by which native species return to area of land that has been degraded. 'Natural regeneration' refers to the natural process by which plants replace or re-establish themselves. Cremer [3] defines natural regeneration as reproduction from self-sown seeds or by vegetative recovery (sprouting from stumps, lignotubers, rhizomes or roots) after the tops of the plants have been killed by fire, cutting, browsing, etc. Temple and Bungey [4] define it as "re growth which occurs naturally after stress or disturbance. It may be growth from seed of either pioneer or permanent species, or growth from lignotuber (e.g., Eucalyptus spp.), rootstock (e.g., Melaleuca spp.), etc, remaining in the ground". Planting seedlings and direct seeding are alternative methods of re-establishing vegetation [5], defined the regeneration individuals as plants between 50 cm and 1.5m. in height. Seedlings were identified as those individuals without any connection with an adult. The natural regeneration is considered the backbone for the continuity and sustainability of the forest. Uneven aged stands have at least three well-represented and well-defined age classes, differing in height, age, and diameter. Often these classes can be broadly defined as: regeneration, pole, and mature. It is necessary to know the different life stages of regeneration for demographic study. Seedling stage is defined as first-year germinant with cotyledons, whose size never exceeds 10 cm according to field measures however, sterile plants without cotyledons, and taller than 10cm are considered as saplings [6].

The greater Darfur region which was once an independent sultanate underwent a series of divisions and segmentation, as a result of which it is now composed of five states. Central Darfur is one of the recently established states with headquarters at Zalingei town. Anthropogenic factors and natural disasters have collectively impacted the natural resources of the region over the years. The current Darfur conflict had its direct and visible impacts on the natural resources and in particular forests and woodlands of the whole region and Zalingei area in particular. Different people view the status of woody vegetation and natural regeneration in the area differently, some people think that the fleeing of communities to IDPs camps gave chance to the natural regeneration to establish at alarming rate and there are some areas that became closed forest as a result, others think that the long and vast empty areas left chance for wood traders to feel large areas and thus making the environment not conducive for natural regeneration. Having that in mind, it is important systematic research to prove whether or not natural regeneration is happing and to know the trend of woody vegetation growth, diversity and densities at the study area. Several parts of the Sudan have been devastated by decades of conflict, which have resulted in the destruction of physical and human resources, and erosion of institutions and social capital. The removal of trees in Sudan has a very negative impact, including increased land and water degradation, and the loss of livelihoods from forest ecosystem services. Darfur's environment is particularly resource poor and suffers from very high natural variability and unpredictability [7]. Compared to previous studies that have been conducted in the region such as (Smith, 1949), Lebon, et al. [8-13], it has been noted that there is a change in the tree species composition in Sudan.

The climates of arid and semi-arid lands are highly variable, particularly in rainfall. Low and erratic variation of rainfall is characteristic of dry lands which have no particular rainfall distribution pattern [14,15]. High aridity is an adverse climatic condition that creates fragile ecosystem, which can easily be upset by adverse human activities. The spatial and temporal variation of rain fall determines the density and composition of the vegetation [16]. The Sahelian droughts which have been observed in the late sixties through the seventies, eighties and nineties in addition to the drought episodes which hit the region and Darfur in particular, had caused considerable changes in the plant species composition and structure as well. These natural factors have accelerated and affected human activities and caused a lot of population movement within and outside Darfur. As a result of these major changes, people's livelihoods have been affected greatly and many of them became more dependent on the natural environment. the current Darfur conflict has also impacted the natural environment greatly however, it is not known if the impact is all negative because some people report on improvement of natural regeneration, while others describe it very negatively. The natural regeneration of the forests and woodlands resources is affected by the conflict. All these factors mention above threats to natural regeneration of the woody species. The aim of this study is to assess natural regeneration of woody species at the study area in central Darfur state in general and Zalingei area in particular.

Material and Methods

Zalingei locality, marked by latitude 12° 30' - 13° 30''N and longitude 30° 23' - 45° 23''E [17]. The study is carried out at Zalingei area which lies between latitude 12° 42' 576'' N (South point) and 13° 08' 055'' N (North point) and between longitude 23° 39' 761'' E (East point) and 23° 25' 835'' E (West point), with altitude varies from 890 m to 1121 m above the sea level. The area lies on the semi-arid Savannah zone, which affected by the elevation of Jabel Marra Massif. A reconnaissance survey was carried out at the study area, during May and July 2013, to assess the general environmental conditions and woody plant community types. The study area was stratified into seven ecological zones according to soil type, slope and distance from Wadi system previously classified and described by Wickens [9]. These ecological zones are namely, contemporary flood plains, lower terraces, upper terraces, clay plains, sedentary plains, lower hill slopes and stony hill slopes. Eleven sites were selected for this study. Site 1 is a contemporary flood plain on Wadi Gallabat Teraje with altitude of 999 meter abve see level (m..a.s.l). Sites 2 and 3 represent lower terraces at Wadi Uyer in Abata with

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altitude of 960 m.a.s.l and Wadi Aribo in Zalingei with altitude of 902 m.a.s.l. Sites 4 and 5 are upper terraces at Wadi Dahab Sharo in Zalingei with altitude 922.2m.a.s.l and Wadi Gallabat Teraje with altitude of 1002 m.a.s.l. Site 6 is clay plain at Wadi Uyer in Abata with of altitude 973 m.a.s.l. Site 7 is sedentary plain at Wadi Uyer Abata with altitude of 980 m.a.s.l. Sites 8 and 9 are lower hill slope at Wadi Uyer in Abata with altitude of 993m.a.s.l and Wadi Gallabat Teraje with altitude of 1016 m.a.s.l. Sites 10 and 11 are Stony hill slope at Wadi Gallabat Teraje with altitude of 1112 m.a.s.l and Wadi Azum in Zalingei with altitude of 944.4 m.a.s.l as shown in Figure 1 . The systematic circular line-plot sampling design and systematic strip sampling after Wiley and Sons [1], was used for this survey. Using the Global Positioning System (GPS), measuring tape (100 m), a compass, four inventories were carried out in the two seasons of 2013 and 2014.

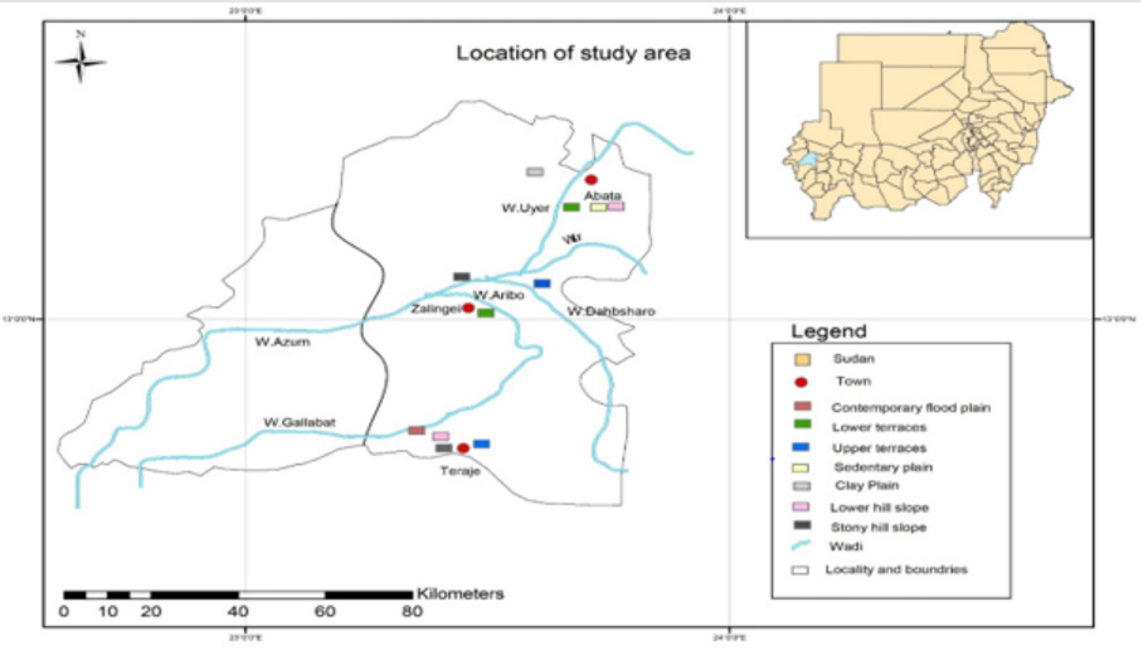

Figure 1: The study sites at Zalingei area modified from Land sat [18].

In the sites described above, sample plots were established, the center of every plot fixed with metal pegs the radii of these plots were 10 m. At Site 4,7,8,9 and 11 were 21 plots per site, size of all sample plot (10m2× 3.14×21× 5)/10000 = (3.3 ha). In site 2, 3, 5, and 6 the area occupied by trees was laid on strip and they were relatively smaller; therefore, strip sample plot was used each of them, The total area of the plots is 12 hectare (200 m × 600 m) with 2 strip (5m× 600m) along the site and the distance between each strip is 100 m, each strip divided into two sample plots. The size of each sample plot was 5m×300m or 0.15 ha. the same was applied for sites 1 and 10, each of them consists of 10 hectare (200 m × 500 m) with 2 strips (5m× 600m), each strip divided into two sample plots Size of each one (5m× 250 m) (0.125 ha). The total number of samples were 129 with different sizes as follow; 105 sample plots the size of each one is 0.0314 ha, 16 sample plots, the size of each is 0.15 ha and 8 samples the size of each is 0.125 ha. The total sizes of all sample plots were 6.7 ha (3.3ha + 2.4ha + 1ha). In the eleven sites, Regeneration and regeneration type and size of seedlings less than 1m or above 1m and survival rates or percentage of all tree species counting, and recording were performed four times recurrently, twice in each season (In August wet season and March dry season in 2013 and 2014). To know the main source of seedlings (seeds or coppice or sprouts) the one sample case of the Chi- square Test was used

$$X^2 = \sum_1^k \left[\frac{(O-E)^2}{E} \right]$$

X^2= Chi- square; O = Observed; E = Expected; K = number of individuals.

The Statistical Analysis System (SAS) was used for data analysis. Regression analysis was used to find the relationship between mature trees and natural regeneration. The (*by-x*) is calculated according to the formula:

$$by.x = \frac{sp}{ssx}$$

Where:

by-x = Regression coefficient

sp = Total sum of squares of variance

ssx =Total sum of squares of independence variable from its arithmetic mean. The Statistical Analysis System (SAS) was used for data analysis.

Result and Discussion

The results indicated that the highest density of seedlings was 75.58/ha for *Acacia seyal*, 75.31/ha for *Albizia amara*, 68.63/ha for *Balanites aegyptiaca*, 58.78/ha for *Acacia senegal* and 41.66/ha for *Dichrostachys cinerea*. However, 22.19/ha for *Acacia nilotica*, 19.03/ha for *Ziziphus spina-christi*, 9.64/ha for *Ziziphus abyssinica*, 7.84/ha for *Acacia girrardii*, 4.18/ha for *Acacia mellifera* and 6.46/ha for *Faidherbia albida* with moderate seedlings density. Other species gave very low densities Table 1. Also, the results showed that all species have more than one source of natural regeneration, such as *Albizia amara*, *Balanites aegyptiaca, Dichrostachys cinerea* which are renewed by seeds, coppice and sprouts. Other species have two sources of regenerations; namely seeds and coppice Table 1. On the other hand, coppice and sprouts are more tolerant to drought and have high survival rate compared to seeds due to the good root system. The number of seedlings/ha (388.77) is less than that of Adam [13] who reported 14607 seedlings/ha. This variation is due to the changes that have occurred in the area during this time lapse in addition, the study of Adam [13] was conducted in the foot of Jebel Marra area while this study wasn conducted in Zalingei area.

Table 1: Source of natural regeneration and density by species in Zalingei.

Species	Seedlings less than one m in height			Seedlings more than one m in height			Seedlings /ha
	Sprout	Coppice	Seed	Sprout	Coppice	Seed	
Albizia amara	37	68.5	81.5	113.3	61.3	143	75.31
Acacia senegal	0	74.7	119.3	0	95.3	104.5	58.78
Faidherbia albida	0	4.8	4.5	0	14	20	6.46
Albizia anthelmintheca	0	0.25	1	0	0	0.5	0.26
Acacia girrardii	0	10.5	24	0	5	13	7.84
Acacia seyal	0	85.8	237.8	0	40.3	142.5	75.58
Acacia sieberana	0	0.5	2.3	0	0.8	1	0.69
Acacia nilotica	0	24	70.5	0	12.5	41.7	22.19
Acacia mellifera	0	6.3	15	0	5	15.5	6.24
Acacia tortilis	0	0	0.3	0	0	0	0.04
Acacia oerfota	0	1	4.5	0	1	4	1.57
Acacia polycantha	0	0	0.3	0	0	0.3	0.09
Ziziphus spina-christi	0	11.3	20	0	9.3	24	9.64
Anogeissus leiocarpus	0	0	0.25	0	0	1.25	0.22
Sclerocarya birrea	0	0	1.5	0	0	0.25	0.26
Dichrostachys cinerea	22	25.5	111.5	25.3	25.5	69.3	41.66
Dalbergia melanoxylon	0	0.5	4.5	0	5	1.8	1.76
Bauhinia rufescens	0	3.35	13.25	0	4.75	11.75	4.94
Xeromphis nilotica	0	5	9.5	0	3.75	6.5	3.7
Balanites aegyptiaca	47.75	37.5	125.3	55.75	75.25	118.3	68.63
Boswellia papyrifera	0	4.75	2	0	2.5	0.75	1.49
Azanza garckeana	0	0.5	0.75	0	1	1. 5	0.34
Combertum glutinosum	0	0	1. 5	0	0	0.25	0.04
Terminalia mollis	0	0	4.75	0	0	2.25	1.04
Average	106.75	364.75	854.3	194.4	362.25	722.4	388.77

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The results indicated that the contemporary flood plain site have less seedlings compared to other sites. *Albizia anthelmintheca, Combertum glutinosum, Sclerocarya birrea, Anogeissus leiocarpus Acacia tortilis acacia polycantha, Faidherbia albida* have less survival rate (Table 2). However, *Albizia amara, Balanites aegyptiaca, Acacia senegal, Dichrostachys cinerea, Acacia nilotica, Ziziphus spina-christi* have highly survival rate. The results also show that seedlings with more than one meter length have better survival rate than those with less than one meter height. It was observed that over grazing, drought and termites have strongly affected the trees seedlings at the summer seasons. Table 2 indicated that the contemporary flood plain site have less seedlings compared to other sites because the area of contemporary flood plain is a sandy soil and often there is only one species Faidherbia albida. The results also show that *Albizia anthelmintheca, Combertum glutinosum, Sclerocarya birrea, Anogeissus leiocarpus Acacia tortilis Acacia polycantha, Faidherbia albida* have less survival rate and this result agree with Ali [18] who mentioned that in Zalingei area there is no natural regeneration of some species such as *Faidherbia albida, Boswellia paprifera, Cordia Africana, Tamarintus indica and Khaya senegalensis.* On the other hand, *Albizia amara, Balanites aegyptiaca, Acacia senegal, Dichrostachys cinerea, Acacia nilotica, Ziziphus spina-christi* have good survival rate and more tolerant to drought and termites. Seedlings of more than one meter height were found have better survival rate compared to seedlings that are less than one meter in height.

Table 2: Natural regeneration of trees in the different site of Zalingei area.

Species	Seasons	CF		LT		UT		SP		CP		LH		SH		Total	S R
		≤1	≥ 1	≤1	≥ 1	≤1	≥ 1	≤1	≥ 1	≤1	≥ 1	≤1	≥ 1	≤1	≥ 1		
Albizia amara	Y1	0	0	0	0	10	2	14	13	0	0	93	105	84	204	523	84.8
	Y2	0	0	0	0	6	3.5	11	19	0	0	58	106	85	200	487	89.5
Acacia Senegal	Y1	0	0	0	0	2	0	33	30	6	4	127	79	48	75	403	82.5
	Y2	0	0	0	0	5	1	73	38	8	5	55	86	34	82	400	77.4
Faidherbia albida	Y1	9	1	29	6	8	1	1	0	0	0	0	0	0	0	56	24.2
	Y2	0	1	19	5	2	2	0	1	0	0	0	0	0	0	30	31.1
Albizia anthel-mintheca	Y1	0	0	0	0	0	0	2	1	0	0	0	0	0	0	3	20
	Y2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia girrardii	Y1	0	0	0	0	3	3	6	2	4	2	20	3	9	5	55	52
	Y2	0	0	0	0	5	0	8	1	10	3	5	6	5	4	49	58.1
Acacia seyal	Y1	0	0	0	0	172	41	4	6	171	90	73	33	11	19	677	48.7
	Y2	0	0	0	0	128	57	13	2	61	88	22	18	15	11	464	47.9
Acacia sieberana	Y1	0	0	1	0	0	0	0	1	0	0	2	3	1	0	7	36.4
	Y2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	50
Acacia nilotica	Y1	0	0	28	8	5	10	6	5	4	6	38	17	19	16	162	75.1
	Y2	0	0	26	11	11	7	8	7	8	5	22	3	14	13	134	65.4
Acacia mellifera	Y1	0	0	0	0	2	0	5	2	10	19	5	0	0	0	44	60
	Y2	0	0	0	0	1	0	1	3	16	15	0	2	0	0	40	54.9
Acacia tortilis	Y1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Y2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia poly-cantha	Y1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0
	Y2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia oerfota	Y1	0	0	0	0	0	0	7	3	0	0	0	0	0	0	14	57.1
	Y2	0	0	0	0	0	0	5	6	0	0	0	0	0	0	11	69.2
Ziziphus spi-na-christi	Y1	0	0	13	2	9	17	4	1	19	13	35	23	1	2	140	65.3
	Y2	0	0	12	5	10	14	1	4	13	12	8	29	3	4	115	73.5

Ziziphus abyssinica	Y1	3	0	9	4	12	28	0	0	2	5	0	0	0	0	64	60
	Y2	1	0	11	4	14	21	0	0	10	4	0	0	0	0	65	49.4
Anogeissus leiocarpus	Y1	0	0	0	0	0	0	0	0	2	1	0	0	0	0	2	33.3
	Y2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
Sclerocarya birrea	Y1	0	0	0	1	2	0	0	0	0	0	2	1	0	0	5	40
	Y2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
Di-chrostachys cinerea	Y1	0	0	43	42	102	17	20	5	5	7	2	3	27	33	307	74.4
	Y2	0	0	40	47	36	29	13	10	12	6	0	0	16	40	250	73
Dalbergia melanoxylon	Y1	0	0	0	0	0	0	0	1	0	0	0	1	2	0	4	50
	Y2	0	0	0	0	0	0	1	0	0	0	4	1	2	1	9	41.7
Bauhinia rufescens	Y1	0	0	1	0	0	0	1	1	4	7	5	4	1	0	25	72.4
	Y2	0	0	2	0	0	0	3	0	7	5	7	5	0	1	30	53.8
Xeromphis nilotica	Y1	0	1	0	0	0	0	0	0	0	0	3	0	7	13	24	77.8
	Y2	0	0	0	0	0	0	0	0	0	0	0	2	7	16	26	59.4
Balanites aegyptiaca	Y1	0	0	13	16	149	157	2	4	1	1	34	20	21	37	455	79.1
	Y2	0	0	16	14	117	162	10	3	15	1	14	41	23	42	450	83.8
Boswellia papyrifera	Y1	0	0	0	0	0	0	0	0	0	0	2	0	8	5	15	30.4
	Y2	0	0	0	0	0	0	0	0	0	0	2	0	3	0	5	25
6Albizia amara	Y1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	3	50
	Y2	0	0	0	4	0	0	0	0	0	0	0	0	0	0	4	80
Combertum glutinosum	Y1	0	0	0	0	0	0	0	0	0	0	2	1	0	0	2	20
	Y2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
Terminalia mollis	Y1	0	0	0	0	0	0	0	0	0	0	0	0	2	5	7	44.4
	Y2	0	0	0	0	0	0	0	0	0	0	0	0	7	0	7	36.4

Note: Were: Y1W = survey in the rainy seasons of first year; Y2W = survey in the rainy seasons of second year; Y1D = survey in the dry seasons of first year; Y2D = survey in the dry seasons of second year; CF =Contemporary flood plain; LT = Lower terraces; UT = Upper terrace; SP =Sedentary plain; CP =Clay plain; LH =Lower hill slope SH = Stony hill slope; SR = Survival rate

Statistical analysis showed that there is highly significant difference between the three sources of seedlings (seeds, coppices and sprouts) for *Albizia amara, Balanites aegyptiaca and Dichrostachys cinerea. Albizia amara, Balanites aegyptiaca* were the main source of seeds followed by coppice and then sprouts, but Dichrostachys cinerea was the main source of seeds followed by coppice and sprouts as shown in (Table 3). The seeds of *Albizia amara, Balanites aegyptiaca and Dichrostachys cinerea* were available with high viability compared to coppices and sprouts happened when the trees are exposed to over cutting and over grazing [19]. In general there was strongly positive and highly significant differences between mature trees and seedlings at $P \leq 0.001$ and $P \leq 0.01$ and there is significant differences between mature trees and seedlings at $P \leq 0.05$ for all trees in various sites except *Faidherbia albida* at lower terraces in Abata , *Ziziphus abyssinica* at lower terraces in Zalingei and *Acacia girrardii* at clay plain Abata. This is because, the adjusted R^2 for the species in these sites are low compared to the other sites, the adjusted R^2 of *Faidherbia albida* at lower terraces Abata , *Ziziphus abyssinica* at lower terraces Zalingei and *Acacia girrardii* on clay plain at Abata were low and this could be attributed to a few number of seedlings for the species in those sites which may indicates a possible change on trees species compositions (Table 4).

Table 3: Difference in the source of natural regeneration using X^2 test.

Species	* Seeds	* Coppices	* Sprouts	X^2 calculated	X^2 Tabulated	L. S
Albizia amara	214	114	132	105.4	13.82	***
Balanites aegyptiaca	238	101	80	61.63	13.82	***
Dichrostachys cinerea	125	45	43	37.06	13.82	***

Note: *= average of four seasons; L.S = level of significantce.

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Table 4: Regression analysis for the relationship between mature trees (T) and natural regeneration per seedlings (S) in Zalingei area.

Species	Site	F – value	Model	Adj R^2	L S
Albizia anthelmintheca	SPA	297.19	S = 0.05+0.987 T	0.9367	***
Balanites aegyptiaca	LTA	64	S = 1.667 + 5.33T	0.95	*
	UTZ	21.57	S = 3.41 + 1.86 T	0.507	***
	UTT	20.22	S = 14.84 + 29.53 T	0.865	*
	SPA	253.94	S = -0.0086 + 0.74 T	0.9267	***
	LHA	41.87	S = 0.25+4.75 T	0.6715	***
	LHT	8.17	S = 1.37 + 0.405 T	0.2638	*
	SHZ	63.23	S = 1.358 + 2.03 T	0.7568	***
Albizia amara	SPA	52.42	S = 0.643+ 0.132 T	0.52.42	***
	LHA	79.13	S = 2.694+0.531 T	0.7962	***
	LHT	60	S = 1.6+ 4.574 T	0.7468	***
	SHZ	181.27	S = 2.24+ 2.7442 T	0.9001	***
Faidherbia albida	CFT	289	S = 0 + 8.5 T	0.98	**
	LTA	0.75	S = 0+ 1 T	-0.091	N. S
	LTZ	52.48	S = 1.316 + 6.95 T	0.94	*
Acacia nilotica	UTZ	36.29	S = 0.1+0.6333 T	0.6383	***
	CPA	25	S =- 2.33+1.667 T	0.888	*
	SPA	63.91	S = 0.29+1.68 T	0.7588	***
	LHA	48.09	S = 0.636+1.53 T	0.7019	***
	LHT	31.18	S = 1.77+2.138 T	0.6014	***
Ziziphus abyssinica	LTZ	11.84	S = 0.58 + 1.74 T	0.783	N. S
	UTZ	11.62	S = 0.65+0.66 T	0.347	**
Acacia seyal	UTZ	20.76	S = 5.99 +1.1 T	0.497	***
	CPA	18.39	S= -15.3+7.257 T	0.8529	*
	SPA	55.51	S = - 0.066+1.769 T	0.8065	***
	LHA	5.26	S = 0.7222+0.944 T	0.1758	*
	LHT	56.79	S = 3.199+1.955 T	0.7361	***
	SHT	196	S = 7.66 +9.33 T	0.98	**
Acacia oerfota	SPA	55.51	S = - 0.061+0.55 T	0.7316	***
Bauhinia rufescens	LHA	36.29	S= 0.1+0.633 T	0.6383	***
	CPA	54.32	S= - 0.136+2.053 T	0.9467	*
Dalbergia melanoxylon	LHT	17.19	S= 0.05+0.95 T	0.4474	***
	SHZ	8.14	S= 0.1+0.9 T	0.2632	*
Ziziphus spina-christi	CPA	109.8	S= 2.84+6.53 T	0.973	**
	LHT	9.84	S= 2.65+6.6 T	0.3065	**
Acacia mellifera	SPA	52.98	S = 0.35+3.65 T	0.7222	***
Boswellia papyrifera	SHT	320	S = 0.65+0.696 T	0.9907	**
Acacia senegal	UTZ	15.38	S = 0+ 0.5 T	0.4183	***
	CPA	32.09	S = - 0.90+ 0.73 T	0.91	*
	SPA	17.02	S = 1.53+ 0.53 T	0.4448	***
	LHA	22.04	S = 5.547+ 0.774 T	0.5127	***
	LHT	11.41	S = 3.053+ 3.95 T	0.3423	**
	SHT	386.29	S = 4.33+ 34.667 T	0.993	**
	SHZ	30.35	S = 1.842+ 3.023 T	0.5947	***

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Dichrostachys cinerea	LHA	10.47	S = 0.0417+ 0.375 T	0.3213	**
	LHT	173.06	S = 0.105+ 1.697 T	0.8959	***
	SHT	97	S = -0.9+ 12.6 T	0.97	**
Acacia girrardii	CPA	1.67	S = 1+0.5 S	0.182	NS
	SPA	533.32	S = 0.62+1.616 T	0.9638	***
	LHA	9.47	S = 0.26+2.35 T	0.2976	**
	LHT	48.93	S = 0.323+2.043 T	0.7056	***
	SHT	117.6	S = 75+3.5 T	0.974	**

Note: LS = Level of significance; * Significant at 0.05; ** Significant at 0.01; *** Significant at 0.001; NS = not Significant.

Conclusion

There is a high relationship between mature trees and seedlings. All species have more than one source of natural regeneration e.g., *Albizia amara, Balanites aegyptiaca, Dichrostachys cinerea* which is renewed by seeds, coppices and sprouts, other species have two sources of regenerations; namely seeds and coppices. The natural regeneration was found to be 389 seedlings per hectare therefore the abundant natural regenerations need to be managed; possible scenarios may include the introduction of sustainable forest management approach. There is a great deterioration in crown vegetation cover at the study area thus, government efforts for the conservation of natural forests would only materialized if local people have been involved, and hence community participation in management of these natural forests is very important.

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