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Assessment of Regeneration Situation in natural and in plantation parts of Elsareef Reserved forest, Kordofan Region, Sudan

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Introduction

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 10cm according to field measures. However, sterile plants without cotyledons and taller than 10cm are considered as saplings (Starfinger, 1997; Closset-Kopp *et al*., 2007), following the 'Oskar syndrome' (Silvertown, 1982). In forest stands that lack catastrophic disturbances, physical conditions such as climate, light, topography, or the ecological characteristics of trees significantly affect the temporal fluctuation of sapling population size (Connell and Green, 2000; MaCarthy and Evans, 2000; Hall and Harcombe, 2001). Saplings adapt morphologically to light gradients; they tend to sustain vigorous growth, in height, in higher-light environments (Cornelissen, 1993; King, 1994; Kato and Yamamoto, 2002). Sprouting at the sapling stage maintains individuals by shoot replacement, and enables saplings to stay small until the onset of favorable conditions (Hara, 1987; Del Tredici, 2001). Seedlings and saplings react against the unfavorable conditions and in contrast they adapt morphologically or physiologically due to changes in the conditions in the surrounding (Eltahir, 2011). Mortality remains one of the least understood components of growth and yield estimation (Hamilton, 1986). Masahiro and Shin-Ichi (2003) agreed that environmental conditions that are favorable for woody plants vary with plants' life-history stage and influence plant population size. The occurrence of regeneration depends on numerous prerequisites such as sufficient volume of viable seeds and appropriate climatic and edaphic conditions for germination and establishment (Lamprecht, 1989). This paper aims to assess the current structure of woody species regeneration and their demography in natural and plantation part of *Elsareef* reserved forest and their capability for continuity and recruitment; and to assess the effect of silvicultural influences and recurrent natural disturbance on regeneration. Also the paper aims to examine the potential effects and relationship between natural and artificial regeneration.

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Materials and Methods

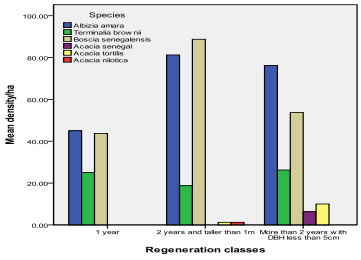
The forest is located in North Kordofan, 133km western Elobied city, and 22 km western *Elkhouyi* town. The area is estimated by 1812.12 ha (FNC, 2009). The forest was reserved to protect the area from desertification, desert encroachment, to keep the forest as shelter belt, to supply the people with fuel wood, timber and NTFPs. In 2009, the forest was subjected to thunders and recurrent wind storms which destroyed 132 and 73 trees of *Terminalia brownii* and *Albizia amara* respectively. The area suffers from fires and grazing. FNC removes dead trees and dry woods to enhance natural regeneration for growth. Systematic sampling was applied; square plots of (20 m*20 m) in size were set up. 40 Plots were spaced every 100 m along linear and parallel transects separated by 200 m from one another. Regenerations were categorized according to age, size and morphology. S1: seedlings germinated last year, S2: with woody stem base, but taller than S1, S3: taller than 1m h and larger than S2. The same classification was used by Starfinger (1991), (Chinchilla, 1994) and (Siebert, 2000). The abundance, absolute frequency, relative frequency, relative density, vitality and mortality of the species were calculated. Species with no regeneration and species represented only by seedlings were identified and encountered.

Results and discussions

There was 6 regeneration species found in natural part, 8 species were recorded in the plantation. The total number of regenerated species in the whole forest was 10. Three species have grown in both natural and plantation parts; *Albizia amara, Terminalia brownii* and *Acacia senegal*. Three other species have grown only in natural part; *Boscia senegalensis, Acacia tortilis, and Acacia nilotica*. Four species have grown only in plantation; *Ziziphus spina –christi, Grewia tenax, Adansonia digitata* and *Tamarindus indica*. (Figure1, and Figure, 2).

Regeneration density in natural and in plantation part of *Elsareef* reserved forest

The 2nd regeneration classes showed the highest density in the forest, followed by slight decrease in density which appears to be in the 3rd regeneration class. In case of 1st year germinated seedlings, there was low density of *Albizia amara and Boscia senegalensis* compared with the 2nd and 3rd classes. The density of *Terminalia brownii* was lower than the density of *Albizia amara* and *Boscia senegalensis* but higher than other species all over the forest. For *Acacia senegal*, there is absolute absence of 1st and 2nd seedling class of regeneration while the 3rd seedling class represented density of less than 20 sapling per hectare in natural part of the forest (Figure,1).



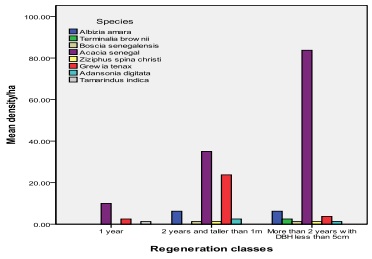


Fig 1. Density of regeneration classes of species in natural part (Left), Fig 2. Density of regeneration classes of species in plantation (right) part of *Elsareef* reserved forest

In figure 2, compared with the density of *Albizia amara, Terminalia brownii, and Boscia senegalensis, Acacia senegal* regenerations scored the highest density. The figure showed that the density of seedlings of *Acacia senegal* 3rd class was much higer than the density of seedlings in

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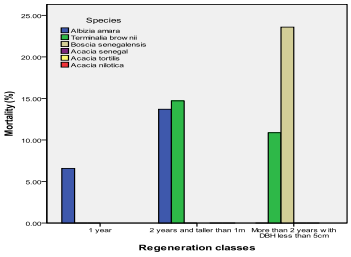
2nd and 1st regeneration classes as well. *Grewia tenax* showed high density in 2nd regeneration class but it showed lower density for 1st and 3rd regeneration classes. *Grewia tenax* would be considered the second species after *Acacia senegal* in plantation in term of density. Other species were also planted for example *Ziziphus spina-christi*. Some species have grown naturally e.g. *Tamarindus indica* and *Albizia amara* but their densities were very low especially for 2nd and 3rd regeneration classes while the majority of other regenerations species were not found as 1st regeneration class.

Regeneration mortality of in natural and in plantation part of *Elsareef* reserved forest

Figure 3 shows the mortality proportion of regenerations in their different life stages in natural part of the forest. It could be seen clearly that mortality was recorded in all life stages of regenerations; first year, 2nd year and 3rd year germinated seedlings. The mortality proportion varied from species to species and it varied within one species too. In natural part, *Boscia senegalensis* (3rd seedling regeneration) was more affected species by mortality. However, the most affected species were *Albizia amara* and *Terminalia brownii*. The affected seedlings stages of *Albizia amara* and *Terminalia brownii* were the 2nd regeneration class which represented 14% and 15% per hectare respectively. The 1st regeneration class of *Albizia amara* and the 3rd regeneration class of *Terminalia brownii* showed very low proportion of mortality.



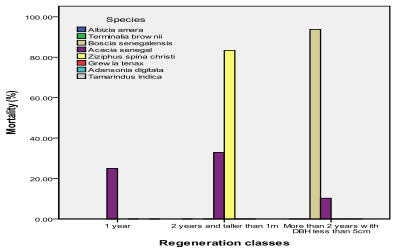


Fig 3. Regeneration mortality in natural part (Left) and Fig 4. Regeneration mortality in plantation part (Right).

Three species were affected as shown in Figure 4 above. For *Acacia senegal*, all regeneration stages showed proportion of mortality while the 2nd regeneration class showed the highest proportion (30% per hectare) and the 3rd regeneration class showed the lowest proportion (10% per hectare). The 2nd seedling class of *Ziziphus spina-christi*, showed higher mortality than 2nd class of *Acacia senegal*. However, the highest proportion of mortality was found in 3rd seedling class of *Boscia senegalensis*. Comparing the mortality in both natural and plantation, the mortality was higher in plantation than in natural part of the forest.

Conclusion and outlooks

Elsareef reserved forest is considered one of the most important forests in Kordofan region. Many people of the surrounding area depend on this forest in their life. The number of tree species is considerable and subsequently the forest is diverse in term of species structure and composition. The family Fabaceae is the dominant family due to the high frequency of its individual trees. The forest situation is getting better because the natural regeneration stock is considerable. The natural part is naturally dominated by *Albizia amara* and *Terminalia brownii* while the plantation part of the forest is artificially dominated by *Acacia senegal*. The situation of *Acacia senegal* requires urgent silvicultural influences so as to resolve the problem of

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regeneration establishment and regeneration mortality. Moreover, seedling should be subjected to enough time during hardening and before transplanting to the field to secure successful establishment and growing. *Acacia senegal* will be a promised tree if rational management could be achieved. The lowest proportions of the regeneration of other tree species indicate their rarity and poor establishment of their regeneration due to competition, termite infection and wild animals' effect. Thus, no chance is seen for continuity and sustainability of these species in the near future. The mortality proportion was high all over the forest and the reasons were recognized, so that soils ploughing before any new planting, weeding at earlier time when competitors grow are necessary. Artificial fertilization or natural fertilization (green manure) should be implicated immediately after weed control or sometimes together with planting. Application of selective herbicides and pesticides is also recommended at earlier and late stages of seedlings growing.

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