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Structure, Composition and Plant-species Diversity in Umabdalla Natural Reserved Forest, South Kordofan – Sudan

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Abstract

This research was conducted in Umabdalla Natural Reserved Forest, South Kordofan. The main objective of this research paper was to assess the tree species diversity in the area and to estimation the changes over successive periods using a ground inventories. Forest inventory in the year 2011 was carried out to constitute 248 sample plots of 0.1 hectare and compared with the previous inventories of 1998 and 2007 carried out by the Forests National Corporation (FNC). Tree species changes were measured. Data from forest inventory and social survey were analyzed using excel 2007 and SPSS version 18. The results showed that the forest is rich in tree species biodiversity where 53 species were recorded. However, the results indicated significant increase ($p > 0.05$) in the number of trees/ha during 1998 to 2007. The analysis of climate data showed that the limiting period where enhancement of species diversity and regeneration occurred was between mid-June and Mid October of the rainy year. During this period strong positive correlation between climate factors was observed. The study concluded that human activities were the main factors influenced diversity and regeneration of trees in the forest.

Keywords

Biodiversity, Natural Reserved Forest, Tree Species, Vegetation

1. Introduction

Species diversity is considered one of the main parts of the forest [1]. Tropical forests contain two-thirds of the estimated 250,000 world's terrestrial plant species, 90 percent of world's insects, and many bird species making tropical deforestation a primary cause of global biodiversity loss. The Natural Forest was found to be the most diverse land use, having high tree diversity, this situation gives an indication of little or no human interference on forest structure, species diversity [2]. Biodiversity in its simplest definition is refers to the quantitative and qualitative complexity of flora and fauna in any given ecosystem [3]. It is woth to mention that some ecologists discussed the influences of species diversity on forest functioning much more than stand structural attributes [4-5]. The extent of biodiversity loss associated with different land use systems has seldom been considered, although many traditional land management strategies have supported biodiversity maintenance. Stand

structural attributes enhance stand productivity despite from the interference of species diversity in natural forests [6] and agroforests [7]. Diversity of the above-ground vegetation and below-ground biota were measured in the range of land use systems at the benchmark sites to address these issues. Although tropical forests contain some of the highest biodiversity of flora and fauna in the world, however, biodiversity at all scales is increasingly threatened by a variety of human-induced structural impacts [6]. Loss of the biodiversity at an alarming rate and an appreciable number of forest species are threatened globally as a result of degradation as well as human activities which is considered as a major driving force with vast implications on changes in watershed ecosystems [8, 9, 10] Disappearance of native forests through clearing for agriculture continues to be a major issue worldwide [11]. Land use change, including expansion of intensive agriculture, is one of the most cited explanations for biodiversity loss worldwide [12]. These changes lead to habitat loss for some species and can even drive species decline and extinction. Biodiversity research in tropical landscapes has been usually conducted in intact-forested areas, with far less emphasis on modified environments [13]. Assessing plant diversity in the tropics is time consuming and difficult, necessitating expertise in tropical plant identification and classification [14]. Species richness refers to the number of species in a particular area, whereas species diversity refers to a combination of richness and relative abundance [15]. The main problem with measuring species richness is that the result depends on the number of individuals recorded. Stand structure complexity found to drive a positive relationship between species diversity and forest functioning [6, 16, 17]. Two main sampling methods are used in forest ecology. One approach is to sample individual trees selected at random within sample plot, and record sequentially the species identity of one tree after another. Secondly, a series of subplots can be established in each plot, and the number and taxonomic identity of all of the trees within each subplot can be recorded, noting the increase in the number of species as additional subplots are surveyed. This is referred to as sample-based assessment [15]. This research article aimed to describe the species dynamic, structure and composition as well as to assess the tree species diversity in Umabdalla Natural Reserved Forest over successive periods.

2. Method

2.1. Study Area

Umabdalla Natural Reserved Forest lies between latitude 11° 41' 52.5" – 11° 46' 40.8" N and longitude 30° 50' 8.4" – 30° 54' 9.4" E with a total forest area is 4396.55 ha, of which 4221.89 ha is natural forest in which the current study was carried out. Other area of 174.66 ha constitutes plantation blocks mainly occupied by, *Khaya senegalensis* and other tree species. It was reserved in 15/05/1961 and registered in gazette number 63. The forest lies along wady Metaimera, which is locally known as Faid Umabdalla. Tree species mainly are *Anogeissus leiocarps, Lannea fruticosa, Albizia amara, Acacia gerrardii, Acacia senegal, Acacia seyal, Ziziphus spina christi, Boswellia papyrifera, Scelerocarya birrea* and *Dichrostachys cinerea* beside other distributed species all over the forest in various ratios [12]. The area was classified according as sub humid region [18]. However, at present the range of isohyets put the state in the savanna zone. The rainy season extends from mid-May to mid-October and the annual rainfall ranges from 400-800 mm. Such climatic characteristics are providing for savanna landscape characterized by combination of trees and grasslands, which allow for grazing and seasonal rain-fed agriculture. Most of the rain is in the form of showers and thunderstorm types. Temperature is averaging 20°C during winter months (November-March), while during summer months (April-June), the average temperature is 35°C. The minimum mean temperature records 29°C while the maximum recorded was 38°C. The savanna climate is characterized by a dry period while the major amount of rains falls within three to four months. The greatest amount of rains falls during July, August and September representing 67% of the average annual rainfall.

2.2. Data Collection

2.2.1. Reconnaissance Survey

Different tools were used to fulfil the objectives of this study; first, a reconnaissance survey was done by the author with the help of the staff from the department of forestry and range sciences, Faculty of Natural Resources and Environmental Studies, University of Kordofan and some graduates from the same faculty. The reconnaissance survey covered Umabdalla Natural Reserved Forest in different aspects such as boundaries, tree composition, and topography and soil types. Also the reconnaissance included the visual observation of the sources of tree cuttings, grazing, and nomad settlement inside the forest, the damage by pest and diseases as well as the gaps in the forest.

2.2.2. Forest Inventory

The inventory survey Umabdalla Natural Reserved Forest was conducted in the year 2011 by the author following the same procedure of the previous inventories which were carried out by the (FNC) in the years 1998 and 2007. Systematic line plot sampling procedure was applied using survey lines with 400 meters interval between lines and 200 meters between sample plots along lines. The system produced sampling representation of (12.5%), also with the aid of Compass (determination of directions) and Global Positioning System (GPS) (coordinates fixation) the same starting point in the North West corner of the forest was fixed and each survey line was oriented in bearing 78° and ranging rods were employed. Circular sample plots were located along lines with an area of (0.1 ha) (radius 17.84 m) for each sample plot. Diameter at Breast Height (DBH) up to 5.0 cm upper diameters was measured using caliber (for small tree diameters) and diameter tape (for large tree diameters). In

each sample plot average tree Height in (m) was measured for each of three trees using height Hypsometer. In addition, all tree species in the sample plot were identified and recorded. Natural regeneration in each sample plot was counted for each tree species including recent saplings and old ones with dbh less than 5 cm. The regeneration counts were recorded in a separate sheet designed for natural regeneration. Gap areas in and adjacent to sample plot were roughly measured for assessment of the Gaps in the forest. Moreover, land use types, human activities such as cultivation inside the forest, animal grazing, nomad settlement, lopping, illegal felling of trees, pest and diseases in the forest were all recorded in remarks.

2.2.3. Data Analysis

The inventory data which was collected from the field was entered in the computer in Microsoft Excel sheet format, pivot tables employed to analyze the invented data and the results in presented in forms of descriptive statistics (means, frequencies, and percentages).

3. Results and Discussion

3.1. In-situ Climate and Biodiversity

This climatic diagram shows the curves for average monthly temperatures in°C versus the average monthly rainfall in mm with a ratio of 1: 4. This means, for instance, that the distance along the ordinates is the same for 20 mm precipitation and 5°C air temperature. Times during which the precipitation curve is above the temperature curve are considered humid, while the remaining periods are classified as arid [19, 20, 21].

The reconnaissance survey showed that Umabdalla Natural Reserved Forest is rich in species diversity (53 species) varying in different densities *Acacia seyal* (Talih*) and Acacia senegal* (Hashab) increased significantly between the years 1998 – 2007. On other hand *Prosopis Africana* (Abosrog) recorded only in the year 1998 and absolutely disappeared in the years 2007 and 2011, the same trend for *Pilostigma reticulate* (Kharoob) and *Grewia mollis* (Basham) not recorded in 2011 inventory. *Bauhinia rufescens* (Kulkul) showed gradual decrease during the years 2007 – 2011. *Dichrostachys cinerea* (kadad) and *Gardenia lutea (Abungawi)* showed pronounced increase through the periods from 1998 – 2011 (Figure 1). The general trend of stocking density of trees is increasing with significant difference ($p > 0.05$) during 1998-2007 and 1998 – 2011, while no significant difference during 2007 -2011.

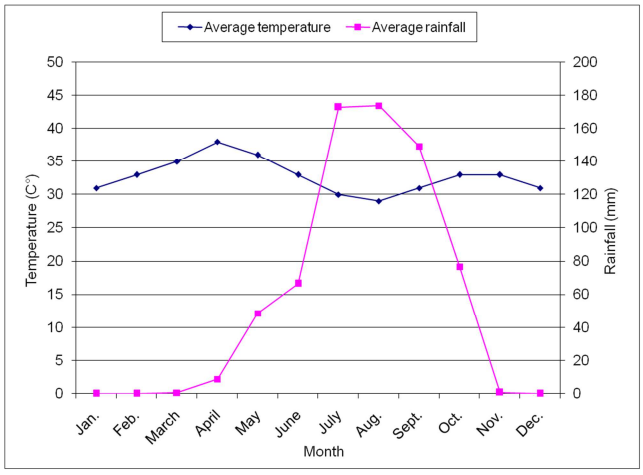

Figure 1. *Average monthly temperature vs. average monthly rainfall in the study area during 1997 – 2011 [22].*

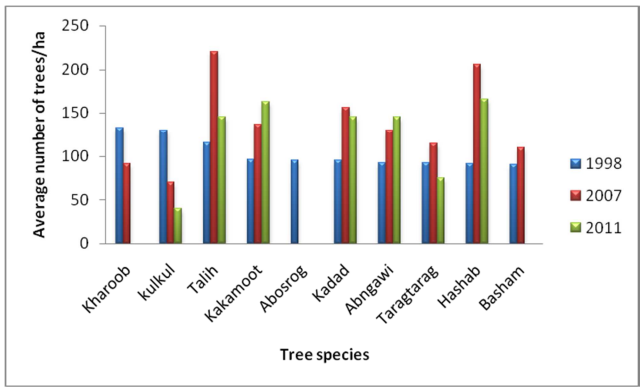

Figure 2. *Species composition and population dynamics of trees in Umabdalla Natural Reserved Forest.*

Biodiversity status is charectrized by high diversity of tree. Considering the existence of tree species in Umabdalla Natural Reserved Forest, the three inventories provided suitable data for comparison. The results from ground inventory revealed that, there were 51 tree species. About 22 species were common and recorded in the three inventories; additional 10 tree species recorded in the inventory in 2011, beside 5 tree species recorded in 2007 inventory and 6 species recorded in 1998 inventory (Table 1, Table 2).

Table 1. *Local name and Latin names of the species found in the inventories (1998, 2007 and 2011).*

Nr.	1998		2007		2011	
	Latin name	**Local name**	**Latin name**	**Local name**	**Latin name**	**Local name**
1	*Gardenia lutea*	Abngawi	*Gardenia lutea*	Abngawi	Gardenia lutea	Abngawi
2	*Dalbergia melanoxylon*	Abnous	*Dalbergia melanoxylon*	Abnous	Dalbergia melanoxylon	Abnous
3	*Prosopis Africana*	Abosrog	*Prosopis Africana*	Not found	Prosopis Africana	Not found
4	*Albizia amara*	Arad	*Albizia amara*	Arad	Albizia amara	Arad
5	*Tamarindus indica*	Aradiab	*Tamarindus indica*	Aradiab	Tamarindus indica	Aradiab
6	*Grewia mollis*	Basham	*Grewia mollis*	Not found	*Grewia mollis*	Not found
7	*Terminalia laxiflora*	Droat	*Terminalia laxiflora*	Droat	*Terminalia laxiflora*	Droat
8	*Disopyros Africana*	Gafal	*Disopyros Africana*	Gafal	*Disopyros Africana*	Gafal

Nr.	1998		2007		2011	
	Latin name	**Local name**	**Latin name**	**Local name**	**Latin name**	**Local name**
9	*Grewia tenax*	Godaim	*Grewia tenax*	Godaim	*Grewia tenax*	Not found
10	*Diospyrus mespiliformis*	Gogan	*Diospyrus mespiliformis*	Not found		Not found
11	*Combretum glutinosum*	Habeel	*Combretum glutinosum*	Habeel	*Combretum glutinosum*	Habeel
12	Acacia Senegal	Hashab	*Acacia Senegal*	Hashab		Hashab
13	*Balanites aegyptiaca*	Higleeg	*Balanites aegyptiaca*	Higleeg	*Balanites aegyptiaca*	Higleeg
14	*Sclerocarya birrea*	Himaid	*Sclerocarya birrea*	Himaid	*Sclerocarya birrea*	Himaid
15	*Ailansis excels*	Ilansis	*Ailansis excels*	Not found		Not found
16	*Dichrostachys cinerea*	Kadad	*Dichrostachys cinerea*	Kadad	*Dichrostachys cinerea*	Kadad
17	*Acacia polycantha*	Kakamoot	*Acacia polycantha*	Kakamoot	*Acacia polycantha*	Kakamoot
18	*Stereospemrum kunthianum*	Khashkhash	*Stereospemrum kunthianum*	Khashkhash	*Stereospemrum kunthianum*	Khashkhash
19	*sieberana Commiphora*	Kook	*sieberana Commiphora*	Kook	*Commiphora sieberana*	Kook
20	*Bauhinia rufescens*	Kulkul	*Bauhinia rufescens*	Kulkul	*Bauhinia rufescens*	Kulkul
21	*Lannea fruticose*	Layon	*Lannea fruticosa*	Layon	*Lannea fruticosa*	Layon
22	*Lannea schimperi*	Melais	*Lannea schimperi*	Melais	*Lannea schimperi*	Not found
23	*Ziziphus abyssinica*	Nabagelfeel	*Ziziphus abyssinica*	Nabagelfeel	*Ziziphus abyssinica*	Not found
24	*Lannea humilis*	Rutrut	*Lannea humilis*	Rutrut	*Lannea humilis*	Rutrut
25	*Anogeissus leiocarpus*	Sahab	*Anogeissus leiocarpus*	Sahab	*Anogeissus leiocarpus*	Sahab
26	*Acacia gerrardi*	Salgum	*Acacia gerrardi*	Salgum	*Acacia gerrardi*	Salgum
27	*Boscia angustifolia*	Sarih	*Boscia angustifolia*	Not found	*Boscia angustifolia*	Sarih
28	*Albizia aylmeri*	Serara	*Albizia aylmeri*	Not found	*Albizia aylmeri*	Serara
29	*Acacia tortilis*	Seyal	*Acacia tortilis*	Not found	*Acacia tortilis*	Seyal
30	*Ziziphus spina-christi*	Sidir	*Ziziphus spina-christi*	Sidir	*Ziziphus spina-christi*	Sidir
31	*Terminalia brownie*	Subag	*Terminalia brownie*	Subag	*Terminalia brownie*	Subag
32	*Secuidacalongipedunculata*	Sugaib	*Secuidacalongipedunculata*	Not found		Not found
33	*Acacia seyal*	Talih	*Acacia seyal*	Talih	*Acacia seyal*	Talih
34	*Boswellia papyrifera*	Taragtarag	*Boswellia papyrifera*	Taragtarag	*Boswellia papyrifera*	Taragtarag
35	*Sterculia setigera*	Tartar	*Sterculia setigera*	Tartar	*Sterculia setigera*	Tartar
36	*Kigelia Africana*	Umshator	*Kigelia Africana*	Umshator	*Kigelia Africana*	Not found
37	*Maerua angolensis*	Untakirna	*Maerua angolensis*	Untakirna	*Maerua angolensis*	Untakirna
38	*Vitex doniana*	Umtgulgul			*Acacia polycantha*	Abosenaina
39	*Crateva adansonii*	Dabkker	*Ficus sycomorus*	Gomais	*Cordia Africana*	Gimbeel
40	*Oxytenanthera abyssinica*	Gana	*Piliostigma reticulatum*	Kharoub	*Acacia mellifera*	Kitir
41	*Vangueria madagascariensis*	Kikir	*Xeromphis nilotica*	Marfaein	*Khaya senegalensis*	Mahogany
42	*Boscia angustifolia*	Kursan	*Calatropis procera*	Osher	*Azadrakhta indica*	Neem
43	*Borassus aethiopum*	Daliab	*Erythrina abyssinica*	Shosh	*Acacia leat*	Shubahi
44	*Grewia villosa*	Gregdan	*Gardenia lutea*	Ummedaka	*Acacia nilotica*	Sunut
	Combretum aculeatum	*sheait*			*Mearua angolensis*	Surhelzaraf
					Adanosonia diggitata	Tabaldi

Table 2. *Alpha biodiversity in Umabdalla Natural Reserved Forest during the period 1998/2007/2011.*

Trees recorded in (1998/2007/2011)	**Trees recorded in (1998/2007) not found in (2011)**	**Trees recorded in (1998/2011) not found (2007)**	**Trees recorded in (2007/2011) only**	**Trees recorded only in (1998)**	**Trees recorded only in (2007)**	**Trees recorded only in (2011)**	**Total**
Gardenia lutea	Grewia tenax Acacia	Acacia tortilis	Maerua angolensis	Secuidaca longipedunculata	Ficus sycomrus	Acacia polycantha	
Dalbergia melanoxylon	Diospyrus mespiliformis			Kigelia Africana	Piliostigma reticulatum	Acacia mellifera	
Albizia amara	Lannea schimperi			Ailansis excels	Calotropis prosera	Maerua angolensis	
Tamarindus indica	Ziziphus abyssinica			Prosopis africana	Xeromphis nilotica	Acacia leata	
Combretum glutinosum	Piliostigma reticulatum			Albizia aylmeri	Erythrina abyssinica	Azadirachtica indica	
Acacia Senegal	Grewia mollis			Boscia angustifolia		Adanosonia digitata	
Balanites aegyptiaca						Acacia nilotica	
Sclerocarya birrea						Cordia africana	
Dichrostachys cinerea						Terminalia laxiflora	
Acacia polycantha						Disopyros africana	
Lannea fruticosa							
Lannea humilis							
Anogeissus							

Trees recorded in (1998/2007/2011)	Trees recorded in (1998/2007) not found in (2011)	Trees recorded in (1998/2011) not found (2007)	Trees recorded in (2007/2011) only	Trees recorded only in (1998)	Trees recorded only in (2007)	Trees recorded only in (2011)	Total
leiocarpus Acacia gerrardi Ziziphus spina-christi Terminalia brownie Acacia seyal Boswellia papyrifera Sterculia setigera Stereospemrum kunthianum Commiphora sieberana Bauhinia rufescens							
22	6	1	1	6	5	10	51

3.2. Tree Species Densities During 1998/2007/2011

Concerning the tree species densities in Umabdalla Natural Reserved Forest, the results from inventories during the years 1998/2007 and 2011 revealed different variation in densities of the trees in hectare. *Acacia seyal* (Talih) and *Acacia senegal* (Hashab) gum arabic producing trees were scored in high densites (more than 200 tree/ha) during the year 2007 and 2011; the density of the trees is increasing when compaired with the number of trees in the year 1998 (less than 120 tree/ha). Also *Ziziphus spini-christi* (Sidir), *Sterculia setigera* (Tartar) and *Tamarindus indica* (Aradaib) increased during the years 2007 – 2011 in average ranging (120 -150 tree/ha). *Adanosonia diggitata* (Baobab) and *Acacia nilotica* were not recorded in 1998 and 2007, however, in the year 2011 the densities appeared very low, (60 tree/ha). *Boswellia papyrifera* (Taragtarg) showed densities of (90 - 120 tree/ha) during the period 1998 -2007 and decreased again in the year 2011 to (80 trees/ha). *Grewia tenax (*Goddiam) was not recored in the year 2011 while in the inventories of 1998/2007 was found in low densites (85 -90 tree/ha) (Figure 3).

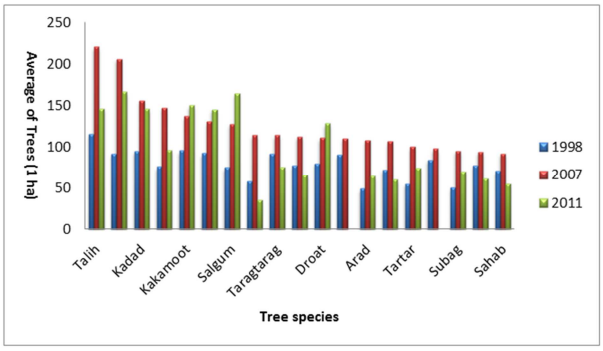

Figure 3. *Tree species densities in Umabdalla Natural Reserved Forest during the years 1998/2007/2011.*

3.3. Natural Regeneration

The general trend of natural regeneration in Umabdalla Natural Reserved Forest during the years 2007 – 2011 according to the results of natural regeneration count is mostly like decreasing. The majority of the trees in the forest showed very rare natural regeneration, which alarming for reduction in the stocking density and tree composition in future of Umabdalla Natural Reserved Forest. The results in this respects indicated noticeable natural regeneration for six tree species namely: *Acacia Senegal* (Hashab), *Acacia seyal* (Talih), *Balanites aegyptiaca* (Higleeg), *Dichrostachys cinerea* (Kadad), *Commiphora sieberana* (Kook) and *Ziziphus spina-christ* (Sidir). Other important species e.g. *Boscia angustifolia* (Sarih), *Combretum glutinosum* (Habeel), *Grewia tenax* (Goddaim), *Dalbergia melanoxylon* (Abnous) and *Combretum Aculeatum* (Shihait) not recorded natural regeneration (Figure 4).

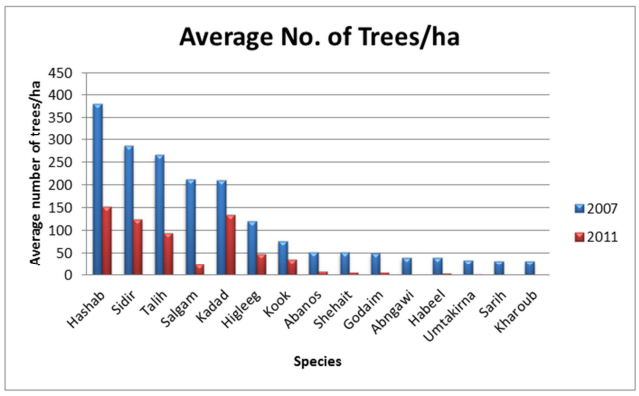

Figure 4. *Average Number of trees/ha of the natural regeneration in Umabdalla Natural Reserved Forest during the years 2007/2011.*

The regeneration in Umabdalla Natural Reserved Forest is facing various causes of damage from local communities, mainly clearance of forest reserve land for agricultural purposes and other activities to satisfy their needs. The removal of trees is created huge gaps for cultivating crops like sorghum and sesame by the community around the forest. Beside that the forest was also affected by civilian war (rebellion) in Nuba Mountains during 1990s and many displaced people settled in and around the forest reserve. After Nuba Mountains' Peace Agreement some parts of the

forest reserve were partially controlled by the FNC as a result improvement of regeneration occurred. Fire also threatining regeneration, especially during first stages of seeds germination. Early fires usually started at the end of the rainy season directly, when tall grasses start to dry. Beside the above-mentioned factors, grazing of some species counts as another cause of deterioration of natural regeneration in Umabdalla forest reserve.

4. Conclusion and Recommendations

Umabdalla Natural Reserved Forest is considered one of the most important forest because it encompassed high level of species diversity. The density of the tree species expressed the potentiality of the forest in term of composition and structure. The land use system in the forest enhanced the protection of the species. The majority of the trees in the forest showed very rare natural regeneration, which alarming for reduction in the stocking density and tree composition in future of Umabdalla Natural Reserved Forest. The uncontrolled grazing, agricultural practices and fires during the dry season in Umabdalla Natural Reserved Forest effected the natural regeneration by seeds negatively specially in the gap area. Involvement of the local people in the forest activities and management will contribute positively in the forest reserve. Establishment of fire lines emeadiately after the rainy season. Control the grazing in the forest particulry the area of replanting so as to secure the survival of the seedlings and newlly regenrated plants. Provision of seedlings in the beginning of the rainy season especially those species which exposed to intensive uses and lacking for or having a very rare regeneration.

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