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Woodland Plant Growth in the Fung Area of the Sudan II. Pattern in the Distribution of Tree Species

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ABSTRACT. A study of the pattern of distribution of six tree species in the Fung area showed that species subjected to least human and animal interference tended to show the same pattern intensity in many sites. On the other hand, highly disturbed species exhibited pattern intensity which varied between different sites. Physical environmental patterns provide special habitats for a number of species. Biotic interference appears to be most important factor determining the general distribution and abundance of the tree species in this area. The present patterns shown by species is attributed mainly to historical influences.

Greig-Smith (1961, 1964, 1979) defined pattern as departure from randomness, and the analysis of vegetation patterns, thus offers information on the hierarchical structure of conditioning factors in plant distribution (Galiano 1982).

In a previous contribution, fifteen community types representative of the vegetation of the Fung area were recognized and their analytic and synthetic characters described (Ismail *et al.* 1984). It was concluded that the present vegetation is a secondary succession brought about by the combined action of intensive cultivation, soil erosion and frequent fires which led over the years to gradual destruction of the original vegetation. In the Fung area, this succession is represented mainly by a number of arboreal species of the genus *Acacia* mixed in varying proportions with *Balanites aegyptiaca* (L.) Del.

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The physical environment was reported (Ismail *et al.* 1984) to influence this ecosystem, in only a limited manner, by providing special habitats, *e.g.* riverine communities occurring on the light soil with abundant moisture or communities restricted to depressions and water catchment sites.

Biotic factors were found to be at least as important as the physical environment in determining the occurrence and performance of the various components of this ecosystem in the greater part of the area. These biotic factors (human activity for subsistence and commercial grain production, wood production for domestic and commercial use and intensive animal grazing) seem to affect the abundance of the different components and appear to impose a quantitative rather than a qualitative change. Halwagy (1962) showed marked differences in plant growth within an exclosure a few kilometers west of Omdurman, Sudan, between the areas outside and inside the exclosure due to biotic factors. As stated by Greig-Smith (1979), other causes may produce patterns, *e.g.* animals, disturbance, fire, historical causes or change.

In this communication, the pattern of distribution of six species is examined to elucidate their responses to prolonged biotic influences.

Table 1. Details of study sites.

Site	Biotic Activity	No. of Species Studied
10	Relic of original vegetation	1
3	Clear-felled in 1952, regenerated	2
8	Protected for 60 years	2
7 9	Vicinity of settlements, domestic wood production, grazing	2 3
2 4 5 6 11 14	Cultivation sites on the clay plain subjected to varying degrees of cultivation fires. Burning for other uses is frequent	1 1 1 1 3 1
12	Riverine sites, intensive grazing	1
13	No burning	1

Methods

Thirteen sites representing various types of biotic activity in the area were chosen for study. Table 1 gives the sites description, and shows the types of biotic activity prevalent in each.

No *a priori* choice of species was made, and only those sufficiently abundant in each site were studied. Those were: *Acacia senegal* (L.) Willd., *A. nubica* Benth., *A. seyal* Del., *Balanites aegyptiaca* (L.) Del., *Ziziphus spina-christi* (L.) Willd. and *Cephalocroton cordofanus* Hochst.

The pattern of the distribution of the species was examined by the pattern analysis technique as described by Greig-Smith (1961, 1964). One transect was set in an apparently homogeneous area in each of the thirteen sites, and species density was chosen for species representation along the transect. The basic unit of each transect was 5 square metres and, although chosen arbitrarily, was considered small enough to expose any pattern likely to be present. The length of transects was 128 units (640 m).

Results

Results of the pattern analysis are shown in Table 2. Although all species had low density at all sites, their representation along transects was adequate to detect the pattern present. There was also a significant positive trend of increasing density along transects at all sites which necessitated applying a correction, by subtracting a covariance term of increasing density with length, to the observed mean square to allow for that trend.

All species exhibited two scales of pattern: a small scale and a larger one. In the analysis of pattern, the size of individuals normally is reflected at small block sizes. Thus, the small scale pattern observed here reflects the sizes of the individual trees. The large scale pattern, on the other hand, is an indication of a factor(s) determining the occurrence and performance of these species. The dimension of this common large scale pattern for all species fluctuated between 80-160 m (block size 16-32).

The large scale pattern is attributed to combined effects of biotic factors which previal in this area. However, examination of the intensity of this pattern (expressed as the ratio of observed to expected variance, see Table 2) at the different sites reveals interesting features of the mechanism of the biotic influences on the different species.

Acacia senegal, an economically important species being the producer of gum arabic, is much favoured, well protected and subjected to least interference by man. The intensity of the large scale showed comparable values in nearly all sites.

Table 2. Results of the analysis of species pattern.

Species	Site	Density/5m²	Peaks at block size							Largest observed variance	95% upper confidence limit	Pattern intensity
			1	2	4	8	16	32	64			
Acacia senegal	3	0.030			*			*		12.00	1.55	378.0
	9	0.008	*			*		*		12.00	1.55	399.0
	13	0.008	*			*	*			2.80	1.80	349.0
	12	0.228			*		*			16.00	1.80	70.0
	11	0.019	*				*			5.00	1.80	256.0
	10	0.056	*		*		*			4.00	1.80	72.0
Ziziphus spina-christi	12	0.120					*			16.00	1.80	123.0
	8	0.016						*		2.00	1.80	125.0
	7	0.016	*		*			*		2.00	1.55	127.0
Balanites aegyptiaca	11	0.008	*					*		4.00	1.55	497.0
	9	0.058			*			*		18.00	1.55	310.0
	6	0.028	*		*			*		7.00	1.55	250.0
Acacia seyal	10	0.016	*			*		*		9.00	1.55	600.0
	4	0.152			*			*		50.00	1.55	327.0
	7	0.078	*		*		*			11.00	1.80	141.0
Acacia nubica	14	0.094	*			*		*		17.00	1.55	180.0
	11	0.105	*					*		20.00	1.55	190.0
	9	0.020	*			*		*		3.00	1.55	166.0
Cephalocroton cordofanus	2	0.065		*		*	*			16.00	1.80	245.0
	3	0.100				*		*		32.00	1.55	323.0
	5	0.100		*				*		20.00	1.55	205.0
	8	0.070		*			*			20.00	1.80	278.0

The low intensity value for site 12 is probably the result of competition from other species as this site is a riverine one characterized by a greater number of taller species than the remaining sites. Competition for space probably occurs during seedling establishment and might result in the suppression and gradual elimination of this species. Site 10 is dominated by *Combretum hartmannianum*, a probable relic of the Combretaceous species once dominant in this area (Kassas 1968) and the presence of *A. senegal* represents an early successional stage, hence its low pattern intensity.

Another species which is least interfered with by man or livestock is *Ziziphus spina-christi*. This species, being very thorny, is not extensively grazed and is of limited domestic or commercial use. In the three sites, where this species was encountered, it has more or less the same pattern intensity.

Balanites aegyptiaca is also one of the species least affected by man. It bears edible fruit, is difficult to fell because of its hard stem and it provides shade for cultivators and shepherds. The hard, tough and fire-resistant stem gives the species additional protection. Again, the intensity of pattern of this species showed fairly comparable values.

Acacia seyal, on the other hand, is highly influenced by man on a very large scale. It is extensively cut for use for fuel and other domestic purposes, or commercial use for charcoal production. Continuous demand for this species resulting in reduction of its population density is reflected by widely varying intensity of pattern in the different sites.

Acacia nubica showed high intensity of pattern in the three sites where it was encountered. This species, although present mainly near settlements, does not appear to suffer any appreciable interference, and domestic animals probably play an important role in its distribution. *Cephalocroton cordofanus* behaved similarly and showed fairly similar intensity of pattern in four sites. This species is unpalatable, being a strong purgative, and not grazed. Like *A. nubica*, it has very limited domestic use.

Discussion

The above results show the importance of biotic disturbances in controlling the general distribution and abundance of the species studied (Greig-Smith 1979, Bouxin and Gautier 1982). The least interfered with species tended to retain the same intensity of pattern, while species highly influenced by man and animals exhibited varying degrees of pattern intensity. In view of uniformity of physical environment in this area (with respect to soil conditions and highly seasonal climate with abundant rainfall), the observed plant cover is interpreted as the product of historical biotic disturbances (Worrall 1960, Greig-Smith 1979).

The Fung area was settled by the Kenana Arabs in the early sixteenth century with the rise of the Fung Dynasty (Arkell 1969). Because of sufficient rainfall staple agriculture has been practised since that time and *harig* cultivation (*cf*, Ismail *et al.* 1984) could be assumed to have been practised since then. Thus, it is reasonable to assume that continuous action of cultivation fires has had its effects on the vegetation. The area under this system of cultivation has continued to increase gradually until 1957 when mechanized farming started. At present, over a million acres are under commercial grain production.

Apart from regular *harig* burning for grain cultivation, other types of burning are practised, *e.g.* for cultivating scattered small holdings, to provide early grazing, or to remove tall grass for cattle paths.

The ecological importance of fire has received the attention of many investigators in tropical and subtropical regions. Trapnell (1959) described woodland burning in Zambia and showed the drastic effects of late burning on regeneration and on total stocking of small trees and shrub layers, but most notably on regeneration of canopy dominants. Hopkins (1965), in studies of savanna burning in Nigeria, found that late burning for five consecutive years reduced tree population by 32%. Most of the losses were in smaller height and basal area classes, regeneration being shown to be virtually prevented. Kassas (1968), discussing the action of fire on *Combretum hartmannianum* reported that in the Fung area fire destroys beyond regeneration *Pilostigma reticulata, Entada sudanica, Stereospermum kunthianum, Acacia sieberiana, Acacia campylacantha* and *Dichrostachys glomerata*. He found further that repeated fire will destroy *Combretum* and the original forest will pass into a phase of open growth of *Balanites*, and, by active regeneration, *Acacia seyal* and *A. fistula* will invade the area.

Another biotic disturbance, of probably equal importance, is animal grazing. Seasonal movements in search of fresh fodder by the local population and their herds of cattle, sheep and camels lead to regular felling of trees to provide fresh leaves and pods, especially during drier parts of the year.

A third biotic disturbance is cutting of trees for fuel wood and charcoal production. This unorganized activity which involves selective felling increases the likelihood of fire which may destroy species non-resistant to fire and saplings of others.

The above factors result in limiting seed production, retardation of germination or coppice regeneration or destruction of seedlings and saplings. The outcome is the limitation of overall density of the various species. Bouxin and Gautier (1982) pointed out that the interpretation of pattern may be complex as it could be morphological at a small scale and environmental at a large scale or sociological at one scale and environmental at another. The observed intensities of species pattern are interpreted here to reflect varying degrees of recovery from biotic interference.

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نمط توزيع أنواع الأشجار فى منطقه الفونج بالسودان

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يدرس هذا البحث نمط توزيع ستة أنواع من الأشجار. وقد أوضحت الدراسة أن الأنواع التى تعرضت تعرضاً محدوداً لأثر الإنسان والحيوان تشكل أنماطاً متشابهة فى كثير من المواقع. وعند تعرض هذه الأنواع للرعى والقطع والحريق تميزت بأنماط غير متجانسة وغير متشابهة فى الأماكن المختلفة.

من المرجح، أن العوامل الإحيائية تلعب دوراً رئيسياً فى توزيع ووفرة هذه الأشجار فى تلك المنطقة.

ويعزى نمط التوزيع الحالى لهذه الأنواع فى المنطقه إلى تعرضها لآثار إحيائية منذ زمن طويل.

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