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VEGETATION UNDER DIFFERENT TREE SPECIES IN *ACACIA* WOODLAND IN THE RIFT VALLEY OF ETHIOPIA

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ABSTRACT: Under-canopy vegetation was investigated in Senkele Sanctuary, Habernosa Cattle Ranch, Abjata-Shalla and Awash National Parks in the Rift Valley of Ethiopia to study the influence of some tree species on the environment under their canopies. Ten species of trees were selected for their relatively bigger canopy size and structure as subjects of the study. The relative abundance of the species in the herbaceous layer under the tree canopy were estimated and subjected to various multivariate numerical data analyses. Patchiness of the habitat on the tree canopy scale aggregated into five distinct groups with little overlap on the landscape scale suggesting that the vegetation beneath the tree canopy responded to environmental variables both under the tree canopies and in the landscape. The landscapes considered showed variation, among other things in altitude, temperature and precipitation. The vegetation under the tree canopies and the aggregations referred to as stratocoena, showed variations in cover, species richness and diversity. Economic implications were drawn for the variations in the herbaceous vegetation across tree canopy and landscape scale. It is argued that suitability of a tree for a particular purpose may depend on the environmental variables across the landscape scale as it does across tree canopy scale. Tree species suitable for agroforestry, developing grazing areas, creating patchy habitats and hence promoting biodiversity could be specific for each landscape considered.

Key words/phrases: Diversity, landscape, niche, patchiness, stratocoena

Nomenclature follows Cufodontis (1953–1972), Hedberg and Edwards, (1989; 1995), Edwards *et al.* (1995) and Edwards *et al.* (1997).

INTRODUCTION

Plant canopy structure is the spatial arrangement of the above-ground organs of plants in a plant community (Campbell and Norman, 1990). Canopy structure can be important in determining the physical environment of other organisms within the plant community, and can strongly influence their success or failure by way of exerting major influence on temperature, radiation regime, interception and transmission of precipitation (Belsky *et al.*, 1989; Campbell and Norman, 1990).

The interaction of trees with herbaceous plants beneath their canopy and other trees in the same or different strata is of interest for both economic and scientific reasons. Among the economic interests are the effects of the tree species on the species beneath their canopy which may be expressed by cover, productivity and diversity of the under-canopy layer (Belsky *et al.*, 1993). The combination of these effects on the herbaceous under-canopy species can be used as criteria for selecting trees for various uses such as for agroforestry, rehabilitation of degraded areas, safeguarding biodiversity and maintaining landscape heterogeneity. The most attractive use of trees for farmers, however, is the interaction between the woody and herbaceous components which may create favourable conditions for improvement of crop quality and quantity, production of fodder, fuel and providing protection against soil erosion (Karamachandi, 1989).

Natural or anthropogenic disturbances create heterogeneity in a landscape. The size and distribution of the patches generated by the disturbance determine the grain of landscape. However, man-made patches caused by anthropogenic influences such as grazing by livestock and cutting of trees and removing under-canopy vegetation may be homogeneous in their effects if plants are removed in proportion to their abundance, or if they are removed preferentially. Preferential removal may favour certain taxa while others are eliminated depending on their relative abundance or tolerance to the disturbing factors. On the other hand, patch dynamics which are influenced by natural phenomena can have internal patch structure with intense edge effects and hence increase the diversity of habitats (Harris, 1984). Maintaining the natural phenomena that created the mosaics (*e.g.*, different species of trees and fire) is therefore necessary so that pattern may continue to exist.

The natural ecosystems of Ethiopia which are important centres of biodiversity and endemism, are under considerable pressure from the rapidly expanding populations. For example, 30 years ago the woodland in the Rift Valley was continuous (Zerihun Woldu and Mesfin Tadesse, 1990). Felling of trees for various domestic uses and making charcoal have decimated the vegetation and most of the land is now cultivated, leaving the woodland fragmented into small patches. Such activities call for studying the ecological variables of the various natural and degraded communities and contribute towards the development of effective strategies for managing natural landscapes. The present study stems from this need.

The specific objectives of this study were:

1. to understand the relationships between the trees and the species underneath their canopy and relationships among the under-canopy species;
2. to estimate some attributes of productivity of the under-canopy herbaceous layer;
3. to obtain an indirect evaluation of the suitability of some important tree species for sheltering food crops or fodder that grow under them; and
4. to get an objective assessment of the heterogeneity of the landscape units.

MATERIALS AND METHODS

Data collection was conducted in four different sites in the Rift Valley in October and November 1994. This period of the year normally marks the end of the summer rains and the beginning of the long dry period in the central and northern Ethiopia (Daniel Gamachu, 1977). The sites considered included Habernosa Cattle Ranch enclosure, Senkele Sanctuary, Abjata-Shalla and Awash National Parks (Fig. 1). Habernosa Cattle Ranch is an enclosure between Lake Abijata and Adami Tullu, a small town, 170 km south of Addis Ababa. Outside the Ranch *Acacia seyal* has been removed for production of charcoal and for various other domestic uses such as fencing and construction of houses (See also Zerihun Woldu and Mesfin Tadesse, 1990). The tree species inside the ranch are thinned periodically to provide optimal spacing for the under-canopy species so that the benefit obtained from the remaining trees could be maximized.

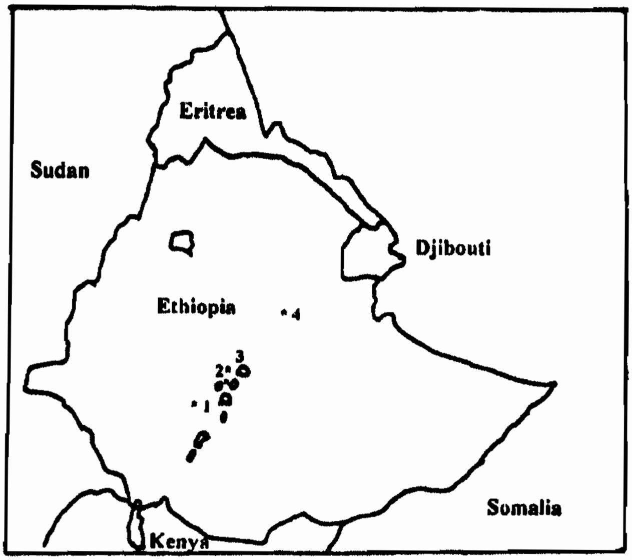

Fig. 1. Location of the study sites in the Rift Valley of Ethiopia. The numbers refer to the study sites, Senkele (1), Abijata-Shalla (2), Habernosa (3) and Awash (4).

Abijata-Shalla National Park is located at 175 km south of Addis Ababa. It is established to protect the avifauna in Lake Shalla and Lake Abijata and a few ungulate species in the woodland. The vegetation here represents the community described as *Acacia tortilis, Acacia senegal* and *Acacia seyal* woodland (Zerihun Woldu and Mesfin Tadesse, 1990).

Senkele Sanctuary was established primarily for protecting the dwindling population of Swayn's hartebeest (*Alcelaphus buselaphus swayni*). It is located at 250 km south of Addis Ababa.

Awash National Park is located at 250 km southeast of Addis Ababa. The park covers an area of 756 km^2. Awash National Park is known for its high population of Oryx (*Oryx gazella*), Soemmering's gazelle (*Gazelle soemerringi*), and Swyne's hartebeest.

Ten tree species were selected for the study based on their size and abundance in the sites. Canopy height, stem width or diameter at breast height (DBH) of the tree species was measured to qualify a tree for the study. This is hoped to minimize the intra specific variation among the trees. Five mature (four in one case only) individuals of each species were selected, marked and mapped. A total of 79 trees were sampled and a total of 151 under-canopy herbaceous species were encountered under the tree canopies. The sample size and the tree species considered in each site are shown in Table 1. The per cent cover of the under-canopy herbaceous species and saplings of tree species were visually estimated and were later converted to the modified Braun Blanquet scale (van der Maarel, 1979).

A data matrix was constructed with the trees in columns and the herbaceous species in rows. The herbaceous species which occurred only once or twice in the entire data set were omitted. The final data matrix constituted 66 rows (under-canopy species) and 79 columns (trees).

Multivariate numerical analyses involving classification, ordination and information theory were used to analyze the data. These methods are known to reveal structure in data by generating clusters of internal homogeneity and reduced entropy. Analyses of diversity and species richness, which are expressions of dominance and heterogeneity were employed to seek the underlying causes for the relative abundance of the species.

Hierarchical average linkage clustering algorithm (Podani, 1988) was used to classify the trees and to produce a dendrogram. Similarity ratio was used as an index of resemblance. The same similarity matrix was ordinated using Principal Components Analysis (PCA). The scattergram from the 2nd and 3rd components (not shown here) gave the same clusters as in the dendrogram. Distinct clusters in the dendrogram which match with those in the PCA scattergram were identified at different levels of similarity. The unconverted data were rearranged following the sequence of the trees in the dendrogram. The average cover values, maximum cover values and the frequency of the species in each cluster were calculated. Only the maximum cover values and the frequencies of species in the clusters were considered to produce the synoptic table. Shannon diversity index and species richness (Shannon and Weaver, 1949) were computed for the distinct clusters and the sites. Shannon index ($H' = -\Sigma p_i \ln p_i$) is among the most commonly used numerical expression of diversity. This index is based on information theory. High diversity is an indication of heterogeneity (Shannon and Weaver, 1949; Simpson, 1949; Pielou, 1977; 1984). The outlier tree number 21 was omitted from the computation of the values.

Table 1. Tree species, identity number, altitude and climatic data of the sites sampled. Five trees, four only in one case were sampled in each site. The identity numbers correspond to those in the dendrogram in Fig. 2. ** = data not available. The annual average rainfall of the nearest town to Senkele (Awasa = 1154 mm).

Species	Identity	Sites	Altitude	Temperature (° C)		Rainfall in mm
				min	max	
Acacia abyssinica	1-5	Senkele	2200	**	**	**
Acacia lahai	6-9					
Acacia tortilis	65-69	Abijata-Shalla	1540	5	16-45	700
Acacia senegal	70-74					
Balanites aegyptiaca	75-79					
Acacia seyal	30-34	Habernosa	1600	5	16-45	700
Acacia tortilis	35-39					
Acacia senegal	40-44					
Balanites aegyptiaca	45-49	Awash I	1000	9.6-22	32-42	619
Acacia tortilis	50-54					
Acacia senegal	55-59					
Balanites aegyptiaca	60-64					
Acacia mellifera	10-14					
Acacia oerfota	15-19					
Acacia nilotica	20-24					
Acacia etbaica	25-29					

RESULTS AND DISCUSSION

The classification of the trees gave five final clusters forming two major groups at a higher hierarchical level (Fig. 2). The final clusters are considered as stratocoena since they are under-canopy communities (Barkman, 1978; Zerihun Woldu *et al.*, 1989). The five stratocoena and 53 of the important under-canopy species, their maximum cover value in the group and per cent frequency occurrence are shown in Table 2. The stratocoena and the average species richness, average cover and diversity are shown in Table 3. The species richness, average cover, diversity and patchiness of the data rearranged into the four sites are shown in Table 4. The species richness, average cover and diversity of the data regrouped according to the tree species are shown in Table 5.

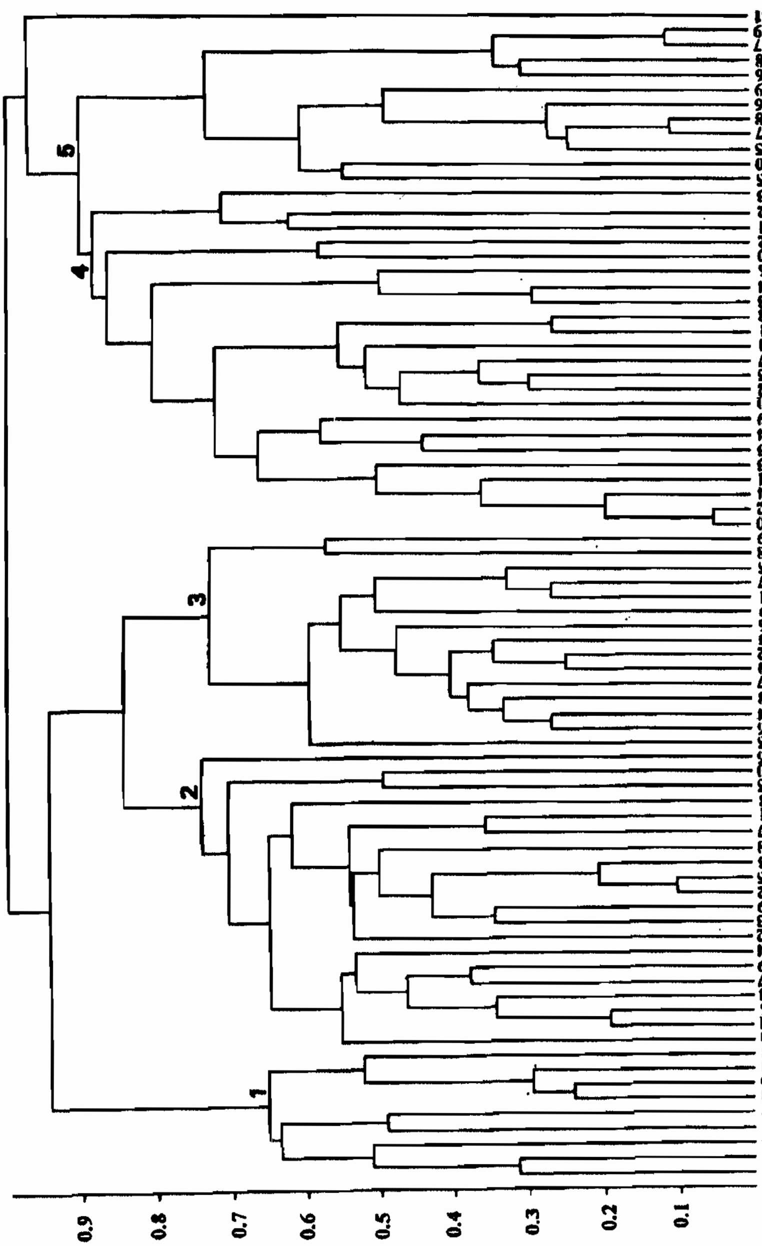

Fig. 2. Dendrogram of the trees in the different sites. The numbers at the base of the dendrogram refer to the sequence of the trees shown in Table 5. The scale on the left refers to distance in similarity.

Table 2. Maximum cover and percent frequency of the undercanopy species in the different stratocoena. (MaxC = maximum cover, Freq. = frequency, the number of relevés in the stratocoenon in which the species occurred).

Species	Stratocoenon 1		Stratocoenon 2		Stratocoenon 3		Stratocoenon 4		Stratocoenon 5	
	MaxC	Freq.	MaxC	Freq.	MaxC	Freq.	MaxC	Freq.	MaxC	Freq.
Abutilon bidentatum	5	89	10	30	1	20	15	9	2	8
Acacia abyssinica	15	56	0	0	0	0	0	0	0	0
Acacia etbaica	0	0	0	0	0	0	0	0	25	42
Acacia mellifera	0	0	0	0	0	0	30	17	0	0
Acacia nubica	10	11	0	0	0	0	20	17	0	0
Acacia senegal	0	0	50	20	10	7	20	13	10	0
Acacia tortilis	0	0	40	10	20	13	10	13	0	0
Achyranthes aspera	25	56	0	0	1	13	0	0	0	0
Balanites aegyptiaca	0	0	5	5	10	7	40	4	5	8
Barleria quadrispina	0	0	0	0	0	0	15	35	10	42
Bidens pilosa	0	0	0	0	15	87	0	0	0	0
Bothriochloa radicans	5	11	0	0	0	0	50	44	0	0
Cenchrus ciliaris	0	0	100	100	10	80	0	0	0	0
Cenchrus setigerus	0	0	70	10	0	0	0	0	0	0
Chenopodium procerum	30	56	0	0	0	0	0	0	0	0
Chloris gayana	0	0	15	10	60	93	0	0	0	0
Chrysopogon plumulosis	0	0	0	0	0	0	50	48	45	92
Cineraria abyssinica	0	0	0	0	15	13	0	0	0	0
Commelina benghalensis	0	0	20	5	1	27	0	0	0	0
Cordia gharaf	0	0	0	0	0	0	20	26	0	0
Cymbopogon sp.	0	0	0	0	0	0	75	22	0	0
Cymbopogon excavatus	0	0	0	0	0	0	0	0	60	75
Dactyloctenium scindicum	0	0	0	0	0	0	25	13	60	33
Digitaria adscendens	0	0	60	10	0	0	0	0	0	8
Eragrostis papposa	0	0	5	15	0	0	0	0	0	0
Erucastrum abyssinicum	0	0	1	5	10	20	0	0	0	0
Euphorbia petitiana	0	0	0	0	1	40	0	0	0	0
Galinsoga sp.	0	0	0	0	5	20	0	0	0	0
Galinsoga parviflora	2	56	0	0	30	50	0	0	0	0
Grewia villosa	2	11	0	0	0	0	40	44	0	0
Harpachne schimperi	0	0	40	10	15	60	0	0	0	0
Heteropogon contortus	0	0	60	15	0	0	0	0	0	0
Hyparrhenia hirta	0	0	10	5	20	53	0	0	0	0
Hypoestes forskalei	10	44	80	70	0	0	0	0	0	0

Table 2. (Contd).

Species	Stratocoenon 1		Stratocoenon 2		Stratocoenon 3		Stratocoenon 4		Stratocoenon 5	
	MaxC	Freq.	MaxC	Freq.	MaxC	Freq.	MaxC	Freq.	MaxC	Freq.
Ischaemum afrum	0	0	0	0	0	0	80	87	0	0
Ischaemum sp.	0	0	10	25	0	0	0	0	0	0
Lippia trifolia	65	100	2	15	1	13	0	0	0	0
Ocimum suave	30	33	0	0	0	0	0	0	0	0
Panicum pusillum	5	11	0	0	0	0	5	13	10	8
Pennisetum sphacelatum	30	56	0	0	0	0	0	0	0	0
Satureja abyssinica	5	44	25	75	70	53	0	0	0	0
Seddera lanceolata	0	0	0	0	0	0	5	9	2	8
Setaria verticillata	0	0	5	5	5	27	0	0	0	0
Sida ovata	0	0	10	10	20	7	10	9	0	0
Solanum incanum	10	67	60	55	40	80	0	0	0	0
Solanum nigrum	5	22	0	0	30	20	0	0	5	17
Solanum schimperi	0	0	5	5	10	27	0	0	0	0
Stephania abyssinica	2	78	0	0	0	0	0	0	0	0
Tagetes minuta	5	22	0	0	80	93	0	0	0	0
Verbascum sinaiticum	2	33	0	0	0	0	0	0	0	0
Vernonia sp.	20	33	0	0	0	0	10	13	0	0
Vernonia cinerea	0	0	0	0	0	0	5	9	10	25
Zehneria scabra	2	56	0	0	0	0	0	0	0	0

Table 3. Species richness, average cover and diversity of the stratocoenon.

Stratocoena	Richness	Cover	Diversity
1	26	86.3	2.254
2	27	121.2	2.045
3	25	113.9	2.305
4	23	77.7	2.394
5	13	60.5	1.688

Table 4. Species richness, average cover, diversity of the sites.

Site	Species richness	Average cover	Diversity
Senkele	26	86.33	2.254
Abyata-Shalla	24	122.30	2.030
Habernosa	30	115.30	2.450
Awash	26	72.92	2.555

Table 5. Species richness, cover and diversity of the data rearranged into the tree species.

Tree species	Species richness	Cover	Diversity	Site
1. *Acacia abyssinica*	23	101.2	2.063	Senkele
2. *Acacia lahai*	23	67.7	2.215	
3. *Acacia seyal*	12	119.0	1.477	Habernosa
4. *Acacia tortilis*	21	125.8	2.108	
5. *Acacia senegal*	16	128.2	2.106	
6. *Balanites aegyptiaca*	18	87.8	2.007	
7. *Acacia tortilis*	18	134.8	2.059	Abijata shalla
8. *Acacia senegal*	17	140.8	1.863	
9. *Balanites aegyptiaca*	11	91.6	1.307	
10. *Acacia tortilis*	14	75.6	2.031	Awash I
11. *Acacia senegal*	14	77.8	2.136	
12. *Balanites aegyptica*	15	84.2	2.193	
13. *Acacia mellifera*	9	101.1	1.318	
14. *Acacia oerfota*	5	62.2	1.070	
15. *Acacia nilotica*	9	33.8	1.825	
16. *Acacia etbaica*	7	67.0	1.208	

Stratocoena and differential species

A species which occurred exclusively or predominantly in one stratocoenon and has attained an average cover value exceeding 25% was considered as a differential species (see Table 2).

1. Senkele stratocoenon

This stratocoenon occurred in Senkele Sanctuary only. It is differentiated by *Lippia trifolia*, *Pennisetum sphacelatum*, *Achyranthes aspera*, *Chenopodium procerum* and *Ocimum suave*. Overgrazing by livestock from the surrounding areas has resulted in the perpetuation of *Pennisetum sphacelatum* similar to overgrazed grasslands in other parts of the highland (see Zerihun Woldu, 1986).

2. Abijata-Shalla and Habernosa Stratocoenon

The herbaceous species under *Acacia seyal* in Habernosa and those under the other tree species in Abijata-Shalla show distinct similarities to warrant grouping under one stratocoenon. This stratocoenon is characterized by *Hypoestes forskalei*, *Satureja abyssinica*, *Cenchrus ciliaris* and *Heteropogon contortus*. It appears that this stratocoenon favours herbaceous species (predominantly grasses) which are presumably more palatable to livestock.

3. Habernosa Stratocoenon

This stratocoenon occurred under *Acacia tortilis*, *Acacia senegal* and *Balanites aegyptiaca*. *Galinsoga parviflora*, *Solanum incanum*, *Tagetes minuta* and *Chloris gayana* characterize the stratocoenon. Grass species in this stratocoenon were out-competed by the non-palatable herbaceous species such as *Galinsoga parviflora*, *Solanum incanum* and *Tagetes minuta*.

4. Awash Stratocoenon

Awash Stratocoenon which made one larger unit could be segregated into two sub-units in which *Acacia mellifera*, *Acacia tortilis*, *Acacia senegal*, *A. nilotica* and *Balanites aegyptiaca* were the canopy tree species of one sub-unit (stratocoenon 4) while *Acacia etbaica*, *Acacia oerfota* and *Acacia nilotica* were the canopy tree species of other subunit (stratocoenon 5). It is interesting to note that the canopy tree species in Stratocoenon 4 are larger in size than those in stratocoenon 5 (see Hedberg and Edwards, 1989).

The differential species of statocoenon 4 included *Grewia villosa, Bothriochloa radicans, Ischaemum afrum, Barleria quadrispina, Acacia mellifera* (sapling) and *Dactyloctenium scindicum.* Five of the differential species in this stratocoenon were grasses. *Acacia etbaica* (sapling) and *Cymbopogon excavatus* were the differential species in stratocoenon 5.

Species richness, cover and diversity

Ranking the stratocoena in increasing order of richness gave 5, 4, 3, 1 and 2 while ranking them in increasing order of diversity gave 5, 3, 1, 2 and 4. Ranking them in increasing order cover gave 5, 4, 1, 3 and 2. Stratocoenon 5 (Awash II) was consistently the poorest in species and the least in cover and species diversity while stratocoenon 2 was the highest in species richness and cover. The analysis has revealed the tendency that species richness, cover values and diversity are associated. In this respect Abijata-shalla and Habernosa areas where *Acacia seyal, A. tortilis* and *A. senegal* are the dominant trees promote high cover, high species richness and higher diversity.

Species richness tended to be directly related to diversity in the data matrix regrouped according to the tree species in each site, R^2 = 0.67 significant at 5% (Table 5). The relationship between cover and species richness and that between cover and diversity was not significant (R^2 = 0.20 and 0.04, respectively). *Acacia abyssinica* and *Acacia lahai* which occurred only in Senkele had the highest number of species under their canopy, but species diversity under *Acacia lahai* was higher than under *Acacia abyssinica.* However, *Acacia abyssinica* which was almost equal to *Acacia lahai* in species richness excelled the former in cover by a factor of 1.5. The fact that *Acacia abyssinica* was lower than *Acacia lahai* in the diversity of under-canopy species may suggest that there were more dominant species under *Acacia abyssinica* than under *Acacia lahai* and that the substratum under *Acacia abyssinica* was more fertile. This claim however needs to be verified by soil analyses.

In Habernosa and Abjata-Shalla, *Acacia senegal* had the highest cover under its canopy. However, *Acacia tortilis* excelled all others in species richness and diversity. *Acacia seyal* had the lowest species richness, cover and diversity of all *Acacia* spp. in Habernosa. This may be attributed to differences in canopy structure and depth among the tree species. The more spread canopy of *Acacia seyal* in general may have created higher light regimes and hence drier conditions which may have favoured more of the grass species than the other non-grass herbaceous species. The universality and the significance of the factors associated with dominance of grass species which lead to low diversity and low species richness should be verified by controlled experiments.

In Awash I *Balanites aegyptiaca* excelled the other tree species in all the parameters considered. In Awash II *Acacia mellifera* had the highest species richness under its canopy and was followed by *A. etbaica*. *Acacia mellifera*, however, excelled *A. etbaica* in cover by a factor of 1.5. Species diversity under the trees in Awash II was low by the standard of the trees in the other sites, but *Acacia nilotica* was the highest in diversity presumably, because of the effect of the Oryx (*Oryx gazella*) which aggregated under the tree canopy seeking for the shade during the hot noon.

Generally we see that every tree species studied had at least one aspect in which it excelled the others. This provides enough clue about the various potentials of the tree species considered.

The rank order of average cover values gave 4, 1, 3 and 2 when the data matrix was regrouped according to the four sites. The low cover value of species in Awash can be attributed to the lower altitude and the more arid conditions in the area (Table 1). Climate, especially erratic rainfall regime, has an obvious effect on species composition and cover of vegetation communities in dry ecosystems (Noy-Meir, 1973). It is also worth noting that other factors which are not estimated may have contributed to the variation in the average cover.

Habitat patchiness

Patch may be defined as a nonlinear surface area differing in appearance from the surrounding area (Forman and Godron, 1986). Patches are embedded in a matrix of the surrounding area which has a different species composition or structure.

Table 4 shows that species richness, average cover and diversity of the under-canopy species increase when the individual trees are regrouped into their species, stratocoena and sites in that order. This suggests that habitat patchiness in the sites were the result of influences of the tree species as well as other attributes in the landscapes. Forman and Godron (1986) referred to such patches which originated as a result of natural dynamics in the environment as environmental resource patches, because the organisms of each patch differ from those of the surrounding matrix as a result of differences in the environmental conditions or resources in the patch.

The classification of the tree species using the under-canopy species as attributes shows us that the vegetation under the trees was far from uniform. Each tree created a mosaic of its own and the mosaics under the same species of tree were generally more similar than those under other species. The grain sizes of the mosaics were determined by the canopy structure of the individual trees and other related factors. Because each site was affected by many different kinds of scales (*e.g.*, edaphic), several grains of pattern may have been superimposed and contributed to the diversity of the horizontal pattern. The clustering of *Acacia seyal* sampled in Habernosa with the tree species from Abijata-Shalla (Fig. 2.) indicates that habitat patches suitable to some under-canopy species could be spatially separated and the persistence of the dynamics in these populations might depend on physical connections between patches.

CONCLUSIONS AND SUGGESTIONS

The analysis of the vegetation data from the four sites protected either as part of a National Park or in the cattle ranch shows that the tree component had wider ecological plasticity than the herbaceous component. The herbaceous component was sensitive to overlapping variations at the microclimatic scale created by the canopy of the tree species and landscape scale corresponding to altitude and those climatic factors associated to it.

The result also suggests that the influence of the tree species on the herbaceous component varied with conditions at the landscape scale; i.e. a tree which is superior in promoting high species richness, cover or diversity in one site could be found inferior in another.

Some tree species manifested superiority in one or two properties over others in the same site. For example, those tree species which promoted high cover and high species richness included *Acacia tortilis* and *Acacia abyssinica* while those which promoted high species diversity included *Acacia lahai*, *Balanites aegyptiaca*, *Acacia senegal* and *Acacia tortilis* depending on the sites considered.

Acacia tortilis and *Acacia senegal* which occurred in Abijata-Shalla, Habernosa and Awash, were superior in species richness and cover in the first two sites while they were the least in Awash. These species can therefore be used for agroforestry under the ecological condition of Abijata-Shalla and Habernosa since their role in promoting high cover can be exploited for better growth and productivity of agricultural crops growing under their canopies. The fact that they showed the most optimal conditions in Abijata-Shalla and Habernosa suggests that their contribution to the habitat or the demand they exerted on the soil nutrient and/or moisture depends on the environmental conditions in the landscape. Grass species were not favoured by *Acacia tortilis* since the relatively favourable conditions under its canopy encouraged herbaceous species which were probably more competitive and preemptive than grass species. Asferachew Abate *et al.* (1998) have shown that the nitrogen and phosphorus level under *Acacia tortilis* are higher than under Acacia senegal and *Balanites aegyptica*. *Acacia seyal* favoured perennial grasses which were more tolerant to stress (sensu Grime, 1979). In this respect, *A. seyal* could be exploited to the advantage of promoting herbaceous species in developing grazing areas. The fact that the tree species in Abijata-Shalla had clustered with *Acacia seyal* from Habernosa may indicate that the more arid conditions in Abijata-Shalla (considering the slightly lower altitude) was also suitable for the species favoured by *Acacia seyal*. This suggests that *Acacia senegal* or *Acacia tortilis* in Abijata-Shalla play the same role as *Acacia seyal* in Habernosa when conditions are drier.

This study shows that selection of a tree species for any useful property should take into account the species composition in the herbaceous layer, species richness, cover and diversity associated with it and the environmental conditions at the landscape scale. The study shows that suitability for agroforestry is not only heritable but is also determined by the environmental conditions at the landscape level.

In order to protect the remaining habitat heterogeneity and to rehabilitate the degraded communities in the sites considered, the rapid settlement and the heavy stocking rate in the *Acacia* woodland between Abijata-Shalla and Habernosa needs to be re-examined. The agricultural activity in these sites is in the process of completely disconnecting the two landscapes and disrupting the mosaic of interconnected populations of plants. The biodiversity of the area would be conserved as a result of flow of genetic material of populations from one landscape to the other if the interconnections could be restored and maintained.

While thinning the tree populations at Habernosa Cattle Ranch, it is important to maintain the tree species ratio so that patch diversity may be conserved.

It is necessary to maintain the dynamics that created the mosaics in Awash (protect the fauna populations and diversity) so that the patch diversity may be allowed to continue.

The preponderance of *Pennisetum sphacelatum* in Senkele which is an indication of a high grazing pressure, presumably from the livestock in the neighbourhood, should be controlled so that the area might serve the purpose worth its name. Settled areas of the Rift Valley, particularly those places experiencing similar environmental conditions as Habernosa may experiment with *Acacia tortilis* to improve their crop yield.

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