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PRESENT STATE AND MULTIVARIATE ANALYSIS OF A FEW *JUNIPER* FORESTS OF BALUCHISTAN, PAKISTAN

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Abstract

Quantitative multivariate investigations were carried out to explore various forms of Juniper trees resulting human disturbances and natural phenomenon. Thirty stands were sampled by point centered quarter method and data were analysed using Ward's cluster analysis and Bray-Curtis ordination. On the basis of multivariate analysis eight various forms i.e. healthy, unhealthy, over mature, disturbed, dieback, standing dead, logs and cut stem were recognized. Structural attributes were computed. Highest numbers (130-133 stem ha^{-1}) of logs were recorded from Cautair and Khunk forests. Highest density ha^{-1} (229 ha^{-1}) of healthy plants was estimated from Tangi Top area while lowest number (24 ha^{-1}) of healthy plants was found from Saraghara area. Multivariate analysis showed five groups in cluster and ordination diagrams. These groups are characterized on the basis of healthy, over mature, disturbed and logged trees of Juniper. Higher number (115, 96, 84, 80 ha^{-1}) of disturbed trees were distributed at Speena Sukher, Srag Kazi, Prang Shella and Tangi Top respectively. Overall density does not show any significant relation with basal area m^2 ha^{-1}, degree of slopes and the elevation of the sampling stands. Present study show that each and every Juniper stands are highly disturbed mostly due to human influence, therefore prompt conservational steps should be taken to safe these forests.

Key words: Juniper forest, Cluster analysis, Bray-Curtis ordination, Ziarat, Balochistan.

Introduction

Juniper forests of Baluchistan are one of the most ecologically important, larger, famous and unique forest of the world. Khattak (1963) presented working plan while Rafi (1965) described various vegetation types of Baluchistan. Champion *et al.* (1965) described these forests qualitatively and included under dry temperate area. Sheikh (1985) suggested aforestation while Ahmed *et al.* (1989) explored natural regeneration in these forests. Ahmed *et al.* (1990b) recognized five morphological different forms of Juniper trees and carried out chemical analysis of leaves. Sixty monospecific stands of Juniper forests were studied by Ahmed *et al.* (1990a). They quantitatively analyzed and described healthy, old, disturbed, male, female and bisexual Juniper trees, exploring population dynamics of this tree species. Vegetation structure and dynamics of *Pinus gerardiana* forests of Zhob district of Baluchistan were also studied by Ahmed *et al.* (1991). Recently ecology and dynamics of this species was studied by Sarangzai *et al.* (2012c). They also showed and described various physical conditions of Juniper trees. Ahmed *et al.* (2010) and recently Ahmed & Shaukat (2012) and Sarangzai *et al.* (2012a, b) reviewed status of vegetation analysis and ethnobotany of Juniper in Pakistan. Achakzai *et al.* (2013) investigated new and old regeneration and deforestation of Juniper trees grown in 5 different localities of Ziarat and they found non-significant variation among these sites. Siddiqui *et al.* (2013) evaluated effect of anthropogenic disturbance on the distribution of conifer trees in different size classes. Sarangzai *et al.* (2013) investigated ecological status and regeneration patterns of *Juniperus excelsa* in north-eastern Balochistan. Siddiqui *et al.* (2010) used Ward's cluster analysis and TWINSPAN for the purpose of classification while DCA ordination was chosen for ordination of species data. Beside these investigations, no advanced multivariate analysis (cluster analysis and ordination) was reported from these forests. Therefore the purpose of this paper is to present a quantitative description and current status of Juniper forests using multivariate techniques.

Materials and Methods

Thirty stands in various Juniper forests of Baluchistan were quantitatively sampled using point centered quarter method (PCQ) of Cottam & Curtis (1956). At each stand twenty five PCQ point were employed after 30 meter distance. Following Ahmed *et al.* (1990a, b) various morphological or physical forms were recognized, based on human disturbances and natural phenomenon. The rating of disturbances / grazing is explained. They were scored in accordance with Enright *et al.* (2005). These forms were

1. Healthy trees (HE) = dark green with dense branches and leaves.
2. Unhealthy (UH) = dull color with open branches.
3. Over mature (OM) = trees greater than 70cm dbh with twisted, hollow or depressed stem.
4. Disturbed (DT) = sign of broken or chopped branches.
5. Di-back (DB) = tree with upper dead branches.
6. Standing dead (SL) = without any sign of life.
7. Logs (LG) = logged stumps remains on ground.
8. Cut stems (CS) = remaining cut stem of a tree.

Density ha^{-1} and basal area m^2 ha^{-1} from each forest were calculated following the method of Mueller-Dombois & Ellenberg (1974) and Ahmed & Shaukat (2012). Above mentioned forms were included during the PCQ sampling.

Data analysis: Correlation coefficient of community among 30 stands was calculated following the method of Czekanowski (1913). Regressions analyses were performed between density / basal area, slope angle / density and elevation / density to obtain relationships between two variables. Ward's cluster analysis (Goodall, 1973; Podani, 2000) was used to classify the different vegetation groups while Bray-Curtis ordination (Beals, 1984; McCune & Beals, 1993; McCune & Grace, 2002) was chosen for the purpose of ordination. The computations were performed using the program PC-ORD version 6.0 (McCune & Grace, 2002; Peck, 2010).

Results and Discussion

`Details of locations, their exact positions on the map, aspect, steepness of the sampling stands, canopy, overall density ha^{-1} and basal area m^2 ha^{-1} of both alive and dead trees of Juniper are mentioned in Table 1. Figs. 1 and 2 show density ha^{-1} of the various types (forms) of alive and dead *Juniper* trees in the study areas respectively. These forests are distributed from 2440m elevation to 3000m elevation on moderate (21^o) to steep (46^o) slopes. Canopy of most of the forests were open.

Table 1. Site characteristics of the sampling area and absolute values of *Juniperus excelsa* forest.

Stand No.	Location and sites	longitude	latitude	Elevation (m)	Slope (^{o})	Aspect	Canopy	Density ha^{-1}	Basal area m^2 ha^{-1}
	(A) Zizri Area								
1.	Tore Sagran	30° 20'	67° 42'	2948	45	W	Open	249	91.22
2.	Khalifat Area	30° 20'	67° 42'	2948	43	NW	Open	241	66.14
	(B) Baba Kharwari								
3.	Prospectus Point	30° 20'	67° 49'	2645	36	NW	Open	343	20.69
4.	Zergut Area	30° 20'	67° 48'	2520	33	E	Open	187	100.69
5.	Shaidan Area	30° 20'	67° 48'	2440	30	E	Open	308	78.48
	(C) Kotal Sarri								
6.	Mulicut Area	30° 22'	67° 48'	2630	29	NE	Open	264	27.44
7.	Sarri Area	30° 22'	67° 47'	2795	26	N	Open	344	12.4
	(D) Cautair								
8.	Karbikach Area	30° 25'	67° 47'	2600	37	S	Open	236	26.01
9.	Khumuk	30° 25'	67° 43'	2570	41	SW	Open	456	104
	(E) Nishfa Valley								
10.	Along Road	30° 17'	67° 59'	2639	46	W	Closed	417	61.87
11.	Ghuza Area	30° 18'	67° 59'	2660	41	W	Open	245	48.71
12.	Prang Shella	30° 24'	67° 50'	2666	40	N	Open	112	57.09
	(F) Pila Forest								
13.	Markhazai	30° 25'	67° 37'	2740	30	NE	Open	180	98
14.	Bian Takari	30° 25'	67° 37'	2680	24	N	Open	204	132.42
15.	Chormul Gut	30° 20'	67° 37'	2600	21	ES	Open	137	37.44
	(G) Sasnamana State Forest								
16.	Sarru Narri	30° 24'	67° 49'	3116	38	NE	Open	258	124
17.	Khawas Neikh	30° 24'	67° 49'	3000	40	NE	Open	201	36
18.	Basharat Shella	30° 24'	67° 49'	2800	32	E	Closed	407	101
19.	School Area	30° 24'	67° 49'	2790	36	SW	Open	187	84
20.	Mir Ahmed Sakhobi	30° 24'	67° 48'	2775	31	S	Open	469	81
21.	Tangi Top	30° 24'	67° 48'	2620	30	S	Open	452	108
	(H) Ghasnak Aghburg								
22.	Arzani	30° 27'	67° 41'	2880	30	SE	Open	203	84.38
23.	Bailza	30° 27'	67° 41'	2775	21	SE	Open	370	90.45
24.	Surri Mana	30° 20'	67° 20'	2690	28	ES	Open	306	27.48
25.	Speena Sakher	30° 20'	67° 20'	2865	33	ES	Open	429	55.32
	(I) Surghund								
26.	Saraghara Area	30° 20'	67° 50'	2510	29	W	Open	200	74.29
27.	Surghund Srag Khazi	30° 33'	67° 14'	2470	32	W	Open	321	107.28
	(J) Spera Ragha								
28.	Tore Sokhar	30° 31'	67° 14'	2695	42	N	Open	334	25.28
29.	Spara Oza	30° 30'	67° 19'	2680	31	N	Open	306	79.97
30.	Prang Shella	30° 25'	67° 16'	2775	39	E	Open	314	40.31

Key to abbreviations: E = East, W = West, N = North, S = South

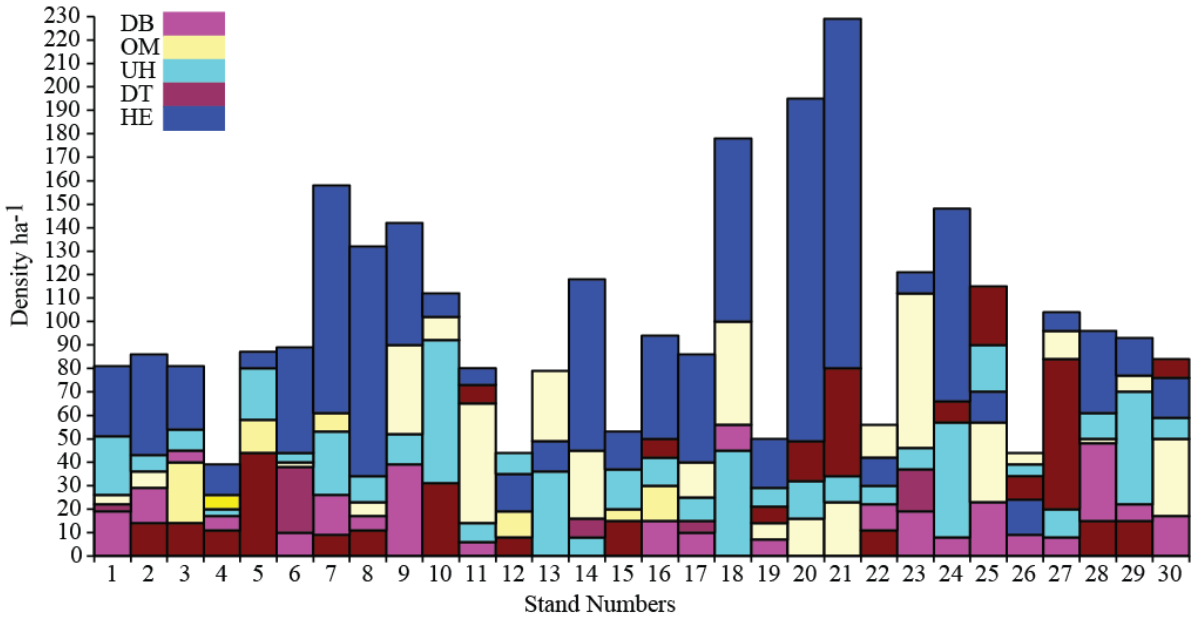

Fig. 1. Density ha^{-1} of different types (alive) of Juniper trees in 30 stands. Two parallel color in the same column show equal density of two types of Juniper.
Key to abbreviations: Refer to Materials and Methods.

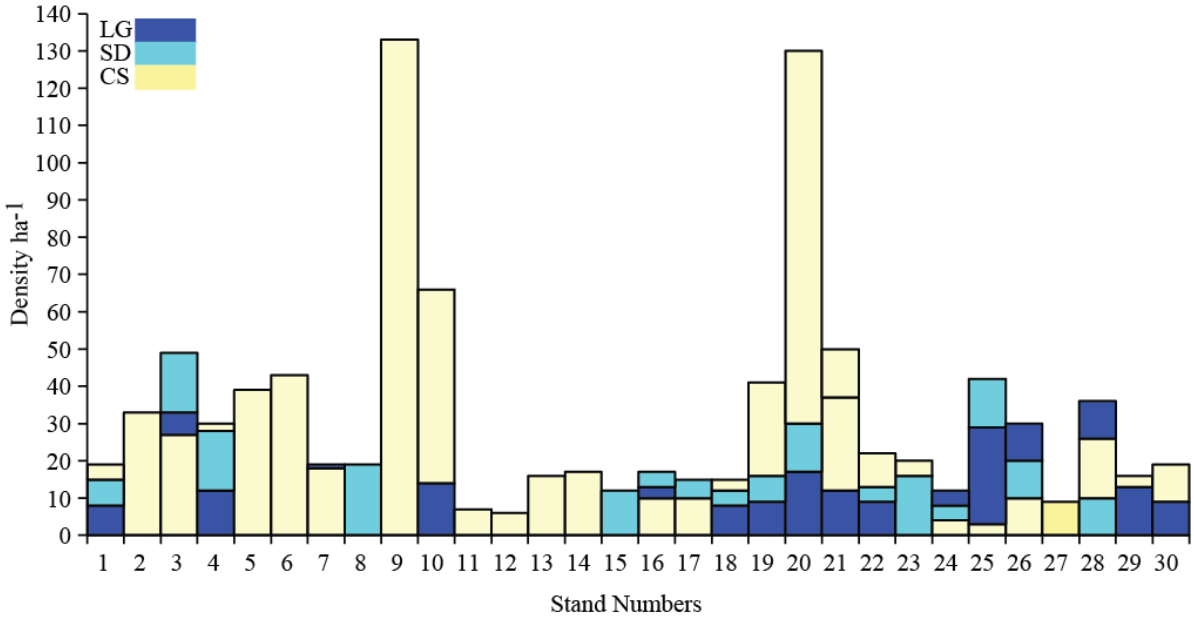

Fig. 2. Density ha^{-1} of different types (dead) of *Juniper* trees in 30 stands.
Key to abbreviations: Refer to Materials and Methods.

Overall density ranges from 112 ha^{-1} to 469 trees ha^{-1} while basal area ranges from 12.4 to 132 m^2 ha^{-1}. Highest density was recorded from stand 20 of Sasnamana State Forest while lowest density was obtained from a stand 12 of Nisfa valley. Pila forest (stand 14) has the highest basal area (132.42) m^2 ha^{-1} while lowest value (12.4) was from Kateu Sarri (stand 7). In contrast to these values highest density ha^{-1} (355) of alive trees were recorded from stand no. 25 while lowest value (106 ha^{-1}) was recorded from stand No 12. Ahmed *et al.* (1990a) investigated different forms of Junipers at Ziarat, Babakhurwari, Cautair and Kuch area of Juniper track of Baluchistan. Its density ranged from 56 to 332 stems ha^{-1} with 9 to 152 m^2 ha^{-1} basal area. Other Juniper forest showed 54 to 152 ha^{-1} density with 5 to 77 m^2 ha^{-1} basal area (Ahmed *et al.*, 1990b). Sarangzai *et al.* (2012) reported density of Juniper from three forests, ranging from 29 to 268 ha^{-1}. *Pinus gerardiana* forests of Zhob district of Baluchistan supported 24 to 930 trees ha^{-1} (Ahmed *et al.*, 1991b). It is noticed that present density values are higher than previous studies. However, it should be kept in mind that Juniper of Rohdmallazi forests were highly disturbed and Ahmed *et al.* (1990a) data was based on three time larger area including

many low density stands. Therefore previous low mean densities are not surprising. Higher amount of dead trees were 177, 133 and 109 ha^{-1} from Mir Ahmed Sakobi (Sasnama State Forests), Khumk (Cautair) and Prospectus Point (Baba Khurwari) respectively. Highest degree of logging practice (130-133 stems) was recorded at Cautair and Khumk forest respectively. A few stands i.e. Prospectus Point (stand 3), Speena Sakher (stand 25), Mir Ahmed Sakhobi (stand 20) and Zergut area (stand 4) showed large number of trees (49, 42, 30 and 28 tree ha^{-1}) of standing dead trees. On the ground higher number of logs (33, 29, 26 and 20 stems ha^{-1}) were also recorded from the sampling sites of Prospect Point, Speena Sakher, Tore Sakhar and Saraghara Area respectively (Figs. 1, 2).

Tangi Top sampling site has the highest number (229 ha^{-1}) of healthy trees while Saraghara area shows the lowest number (24 ha^{-1}) of healthy trees. Highest numbers (92, 80, 80 and 77 trees ha^{-1}) of unhealthy Junipers were found at Nishfa valley (stand 10), Shaidan area (stand 10), Speena Sakher (stand 25) and Spara Oza (stand 29) sampling sites respectively. Except Surri Mana sampling site all sites show over mature trees, however stand 18 of Basharat Skella, stand 10 of Nisha valley, stand 27 of Surghund Srag Khazi, stand 9 of Khumuk and stand 11 of Ghuza area have 111, 102, 96, 90 and 73 trees ha^{-1} over mature Juniper trees. Unhealthy Juniper from at Rodhmallazai (Ahmed *et al*., 1990b) ranged from 0 to 52 ha^{-1} while over mature trees were from zero to 34 with one exception of 112 stem ha^{-1}. Over mature Juniper from 60 stands (Ahmed *et al*., 1990a) ranged from 3 to 135 stems ha^{-1}. Sarangzai *et al.* (2012c) reported 4 to 55 over mature individual tree ha^{-1}. Present investigation recorded higher number of over mature trees. This may be due to the fact that in present study selection of stands was restricted to the least disturbed sites.

Sign of disturbance (chopped branches, cutting of secondary stems) are common in Pakistani forests. Higher number of disturbed trees ha^{-1} were recorded from Speena Sukher, Surghund Srag Khazi, Prang Shella, Tangi top, Ghunza area and Surri Mana with 115, 96, 84, 80, 73 and 66 Juniper individuals ha^{-1} respectively. In contrast to present study, disturbed and logged trees at Juniper track (Ahmed *et al.*, 1990a) were zero to 72 and zero to 194 ha^{-1} respectively. Rodhmallazai forest have zero to 25 disturbed and zero to 38 ha^{-1} logged trees. Higher number of disturbed and logged trees showed increased intensity of human disturbances in these forests. Die back trees are also characteristic of Juniper forest in Baluchistan. Higher intensity of this phenomenon was recorded from Tori Sokhar (48), Basharat Shella (45), Prospect Point (45) and Khumuk sampling area (39 ha^{-1}). Overall density ha^{-1} and basal area m^2 ha^{-1} show no significant relation (Sarangzai *et al.*, 2012c; Kausar *et al*., 2013; Mehmood *et al*., 2014) nor the slope and elevation show any relationship with these two variable, may be due to the human disturbances. However Juniper density and basal area from Juniper Track and Rodhmallazi forests showed significant relation as recorded by Ahmed *et al.* (1990a, b).

Similarity index (not presented here) among these stands show 13 to 69% dissimilarity. Only 50 stands pairs showed 50% dissimilarity between different groups. Among 30 stand pairs i.e. 4-27, 9-12, 9-15, 9-26, 10-12, 11-12, 12-20, 12-21, 12-25, 12-27, 13-20, 13-21,13-24, showed 60 or above 60% dissimilarity.

Two dimensional Bray-Curtis ordination (Fig. 3) of 30 stands and their possible groups on axis 1 and 2 showing 55% of the total variance while Siddiqui *et al.* (2010) evaluated the variance of 99.36% for first three components together while studying the vegetation of conifer trees. Five groups may be divided after applying ordination technique. Stand No. 4, 12, 13, 15, 19, 22 and 26 forming a group D occupied the extreme lower right corner of the ordination diagram. Group B comprises of stand no. 11, 25, 27 and 30 is located on the slightly lower left side of the axis 1 and 2. Another group A contained four stands *i.e.* 9, 20, 21 and 24 positioned extreme upper side of the Fig. 3. Largest group E which is composed of stand no. 1,2,3,6,8,16,17 and 18 is distributed middle to lower toward left side of the two axes. Stand 14 which is situated with group E in cluster diagram but in ordination diagram it is accrued as isolated stand, it may be due to different strategy. The last group C based on stand no. 5, 7, 10, 18, 23 and 29 situated among A, B and E groups, showing slightly over lapping situation between lower two group of the ordination diagram.

The dendrogram (Fig. 4) classifies the different form of Juniper trees into five groups in which group A has highest (421) overall mean density ha^{-1} while the group D has lowest (168) overall density ha^{-1}. Group C, B and D have 352, 327 and 275 overall individuals of Juniper on ha^{-1} basis, respectively.

The groups extracted from Ward's cluster analysis are readily being superimposed on Bray-Curtis ordination. Each group of both ordination and cluster diagram has some specific characteristics. Group A is dominated by highest average number (177 ha^{-1}) of healthy and highest number (77 ha^{-1}) of cut stump. Group B is dominated by highest number (92 ha^{-1}) of disturbed Juniper while the healthy Juniper were comparatively low (85 ha^{-1}) in number. This group also shows 2nd highest number (69 ha^{-1}) of over mature plants and considerable (14 ha^{-1}) di-back plants. Group C has less number (124 ha^{-1}) of healthy while the highest number (60 ha^{-1}) of unhealthy and over mature (81 ha^{-1}) plants. Cut stem are also 2nd highest (32 ha^{-1}) in number in this group. Group D is characterized by nearly similar number of healthy (36 ha^{-1}), over mature (34 ha^{-1}) and unhealthy (32 ha^{-1}) Juniper. On the basis of healthy plants, group E has 3rd position (94 ha^{-1}), while unhealthy and over mature plant density was 41 and 39 ha^{-1} respectively. In this group disturbed, cut stem and di-back have almost same density *i.e.* 21, 21 and 23 ha^{-1}. Present studies indicated that number of disturbed, logged stem and standing dead trees were increased in recent years due to the increased population growth and illegal cutting of the trees. Ward's cluster analysis successfully classified similar stands on the basis of morphological forms while ordination separated different stands on the basis of dissimilarity among stands and groups. Both multivariate techniques provided 5 groups based on similar stands. Each group may be identified or characterized on the basis of few characteristic. Therefore both multivariate techniques (classification and ordination) are important to understand the relationship among groups of stands or among stands (Ahmed, 1984). On the basis of present results it may be concluded that these forests are degrading due to anthropogenic activities. Therefore prompt action should be taken to conserve these rapidly degrading unique Juniper forests.

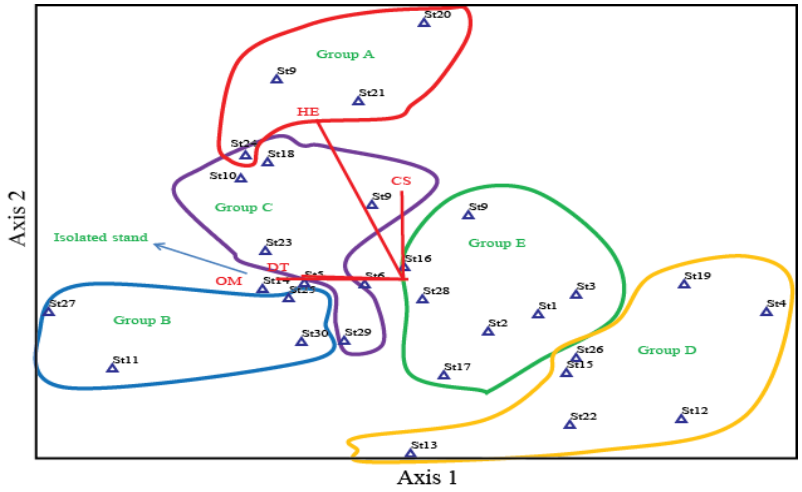

Fig. 3. Five groups of stand displayed on two dimensional Bray-Curtis ordination. Details of stands are mentioned in Table 1.

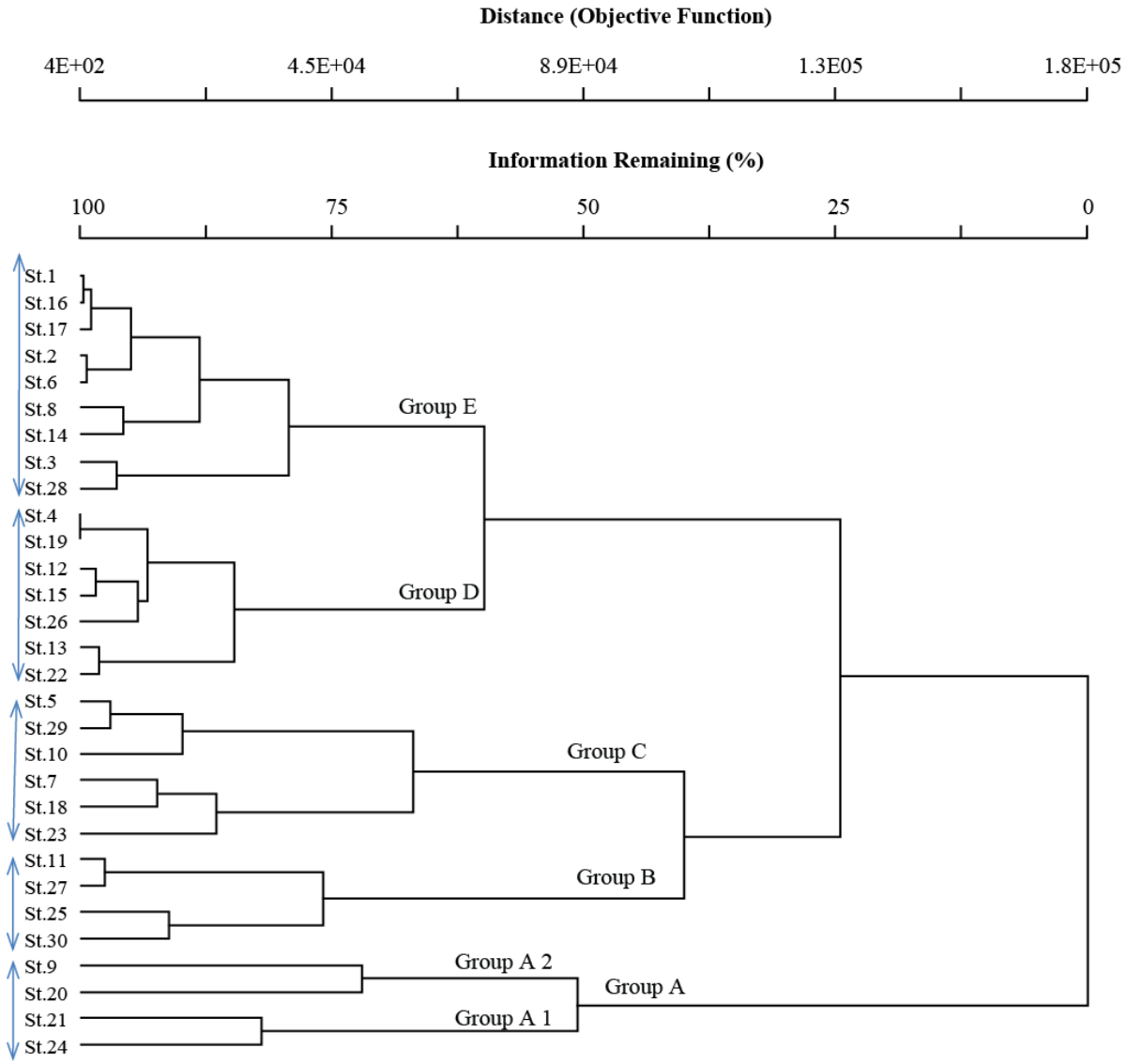

Fig. 4. Five groups of different types of vegetation are extracted by Ward's cluster analysis. Details of stands are mentioned in Table 1.

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