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# Impact of habitat heterogeneity on plant community pattern in Gurbantunggut Desert

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**Abstract:** This paper reports a geomorphologic landscape investigation, vegetation survey and soil sampling at 14 sites across the Gurbantunggut Desert between 87°37'09"-88°24'04"E and 44°14'04"-45°41'52"N. The study encountered 8 species of low trees and shrubs, 5 of perennial herbs, 8 of annual plants and 48 of ephemeral and ephemeroid plants. These species of plants represent one-third of the species found in the Gurbantunggut Desert, and their communities make up a large proportion of desert vegetation with great landscape significance. In the investigation we found that the plant communities are accordingly succeeded with the spatial variation of macro-ecoenvironment. Using Principal Component Analysis (PCA) and Correlation Analysis (CA) we found that the micro-ecoenvironment heterogeneity of aeolian sandy soil's physical and chemical properties such as soil nutrient, soil moisture, soil salt, pH etc. only impacted the diversity of herb synusia (PIEherb) of the desert, with a negative correlation. Meanwhile, the impact of microhabitat on the plant community pattern with an antagonistic interaction made vegetation's eco-distribution in a temporary equilibrium.

**Key words:** impact; habitat heterogeneity; plant community pattern; Gurbantunggut Desert

## 1 Introduction

Study on the interrelationship between vegetation patterns and their habitat heterogeneity is important to recover and rehabilitate the desert vegetation, stabilize the desert ecosystem and prevent desert expansion. Domestic and foreign researchers have carried out many studies on this topic (Archer *et al.*, 2002; Bolling *et al.*, 2000; Chen *et al.*, 2003; Dasti *et al.*, 1994; Gu *et al.*, 2002, Li *et al.*, 2001; Li *et al.*, 2001; Liang *et al.*, 2003), which have used and refined statistic technologies to analyse this kind of study. Dasti *et al.* (1994) used TWINSPAN and DCA statistical packages to analyze the composition and structure of plant communities and the interrelationship with their environmental factors in two deserts in Pakistan. Bolling *et al.* (2000) simplified the problems of vegetation and soil recovery beside desert roads in Nevada, America by applying PCA software to combine complex soil physical and chemical properties into several integrated factors. Chen Peng *et al.* (2003) described the spatial heterogeneity of vegetation and soil characteristics in oasis-desert ecotones using a variance function, and carried out data processing using geo-statistics $GS^+$ software. Zhang Yuanming *et al.* (2003) clarified the composition and spatial distribution of vegetation and environmental factors in the Tarim River catchment by statistic software TWINSPAN and CCA. Other researchers have illuminated the relationship of plant community patterns and environmental heterogeneity using correlations between plant community diversity indices and sampling sites. Many researchers in China have utilized this kind of method to carry out research work that has intensified their understanding of the relationships between plants, soils and landscape. For example, Li Xinrong *et al.* (2001) studied shrub community diversity on the Ordos Plateau, Chen Yaning *et al.* (2003) discussed the

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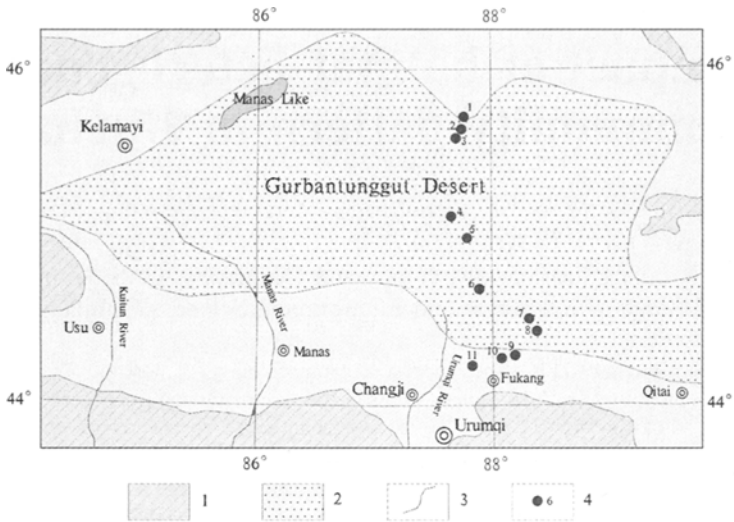
influence of groundwater on vegetation distribution in the lower reaches of the Tarim River, and Gu Fengxue *et al.* (2002) analyzed the correlation between soil salinization and plant community diversity in the southern margin of the Gurbantunggut Desert.

The Gurbantunggut Desert is the second largest desert, but the largest stable and semi-stable desert, in China. Investigations of terrain, landform, hydrology, vegetation distribution and other important environmental factors have been carried out in the late 1950s (Hu *et al.*, 1962), but the interrelationships were only qualitatively discussed. Some quantitative research findings on the desert have been reported in recent years, but these only emphasized research on a single site or individual plant species (Qian *et al.*, 2003; Wang *et al.*, 2003). Qian *et al.* (2003) started to report the impact that habitat factors had on vegetation patterns in the periphery of the desert.




1: mountains; 2: desert; 3: rivers; 4: sampling sites

Figure 1 Distributed area of Gurbantunggut Desert and sampling locations

This paper aims to compare geomorphologic landscape with observations of composition, structure and distribution of plant communities across the Gurbantunggut Desert between 87°37'09"E and 88°24'04"E (Figure 1). It employs systematic analysis of aeolian soil samples and the research techniques and PCA statistic software mentioned above to elucidate the relationships between habitat heterogeneity and plant community diversity.

## 2 Study area and methods

### 2.1 Study area

Gurbantunggut Desert is located in the semi-closed Junggar Basin, where a vast desert landscape has developed on the deep, loose Quaternary sediment. The sand dunes are mainly of the longitudinal form, but checkerboard-shaped and honeycomb-shaped forms also present, with a height of 10-50 m. The desert is a temperate one with a drought climate (annual precipitation: 80-160 mm) and an annual mean temperature of 5-5.7°C (Temperature extremes: highest over 40°C; lowest below -40°C). The annual average evaporation is 2000-2800 mm, and gales of over 8 forces occur on 25-77 days from the center to the margin. There is little surface runoff. In the desert margin the groundwater is over 5 m deep, while in the desert interior it is below 16 m deep. In winter, snow accumulates to 10-30 cm, and a frozen soil layer forms due to a cooling-lake effect in the basin (Wei *et al.*, 2002; 2003). In stable dunes this layer occurs at 180 cm and in mobile dune at 90 cm.

The stable and semi-stable aeolian sandy soils dominate the Gurbantunggut Desert. Stable aeolian sandy soil is distributed in the interdune lands and the middle/lower slopes of the dunes. Semi-stable aeolian soil is found on the middle and upper/middle slopes. Psammophyte and drought-tolerant plants are richer and their life forms are more diverse in the Gurbantunggut Desert compared with the Taklimakan Desert and other famous deserts (Zhang *et al.* 2002).

The study area crosses through the desert from south to north, with the geographical coordinates of 44°14'04"-45°41'52"N and 87°37'09"-88°24'04"E.

## 2.2 Methods

Between May and June 2003 we investigated 11 sampling sites, and selected 25 quadrats for vegetation investigation according to differences in the sand dune forms in the study area. Quadrats of 10m × 10m were chosen for shrubs, 20m × 20m for small trees and 3 quadrats, each of 1m × 1m, were chosen for herbs. The 'herb' quadrats were arranged along a diagonal, nested within the shrub quadrats. We recorded species presence, frequency and abundance (herbs), soil cover percentage, and plant height and crown diameter. Within each quadrat we collected soil samples for physical and chemical analysis from the soil layers of 0-10, 10-20 and 20-30 cm. (Subsequently the samples from the 0-10 and 10-20 cm were combined for analysis because weak soil-forming processes in these surface aeolian sandy soils resulted in poor soil differentiation.)

Each sampling site was located with GPS, and the height above sea level was obtained.

Plant community patterns can be expressed by the spatial variation of community diversity indices. We considered that there were better correlations available between diversity indices than those in common use (Qian *et al.*, 2003; Qian *et al.*, 1994; Zhang *et al.*, 2002) and that the species important value of vegetation is a better measuring index for diversity (Zhang *et al.*, 2002). Two sensitive indices to the composition and structure of plant communities (Qian *et al.*, 2003) were chosen: (1) Simpson ecological dominance C, $C = \sum \frac{n_i^2}{N^2}$. In the formula $n_i$ is the importance value of $i$ species and $N$ is the summation of all species' importance values in the community (Zhang *et al.*, 2002); (2) Herbert diversity index PIE (Probability of Interspecific Encounter), $PIE = \frac{N}{N-1}(1 - \frac{1}{N^2}\sum n_i^2)$. In this formula $n_i$ is the number of the $i$ species and $N$ is the summation of all the species' numbers in the community (Qian *et al.*, 1994; Wu *et al.*, 1983).

The paper analyzed the spatial variation of environmental factors and their impact on plant community diversity using Principal Component Analysis (PCA), Correlation Analysis (CA), processing the data with SPSS and Excel.

# 3 Results and discussion

Two hundred and eight higher plant species had been previously recorded and collected in Gurbantunggut Desert which belonged to 11 life forms (Zhang *et al.*, 2002). We counted 8 species of low trees and shrubs, 5 of perennial herbs and 48 of ephemeral and ephemeroid plants under 18 families in the study area. According to the dominant species of every synusia, community structure and landscape characteristics we divided them into 19 plant associations (Table 1). Based on the principle of dominant species for Chinese vegetation classification, these associations belong to 5 communities: *Haloxylon persicum*, *Ephedra distachya*, *H. ammodendron*, *Ceratoides lateens* and *Seriphidium santolina*. These plant communities vary with the changes of geomorphologic landscape and eco-environment. Generally, *Ceratoides lateens* communities dominate desert plains developed by steepification in the northern margin of the desert. The low land of the desert and desert plains in the north and south margins of the desert are dominated by *H. ammodendron* communities. *Ephedra distachya* communities are mainly distributed on the interdune lands and lower-middle slopes of dunes. *H. persicum* communities are developed on the tops and slopes of semi-stable, semi-mobile and mobile dunes. And, *Seriphidium santolina* communities grow on the tops and slopes of semi-stable dunes in complex longitudinal dunes. PIE and C varied with the changes in the micro-morphology of the landforms (Figure 2). Comparing different dunes, we found that the vegetation associations succeeded to higher diversity indices from the interdune lands to the tops of the dunes, and the plant community

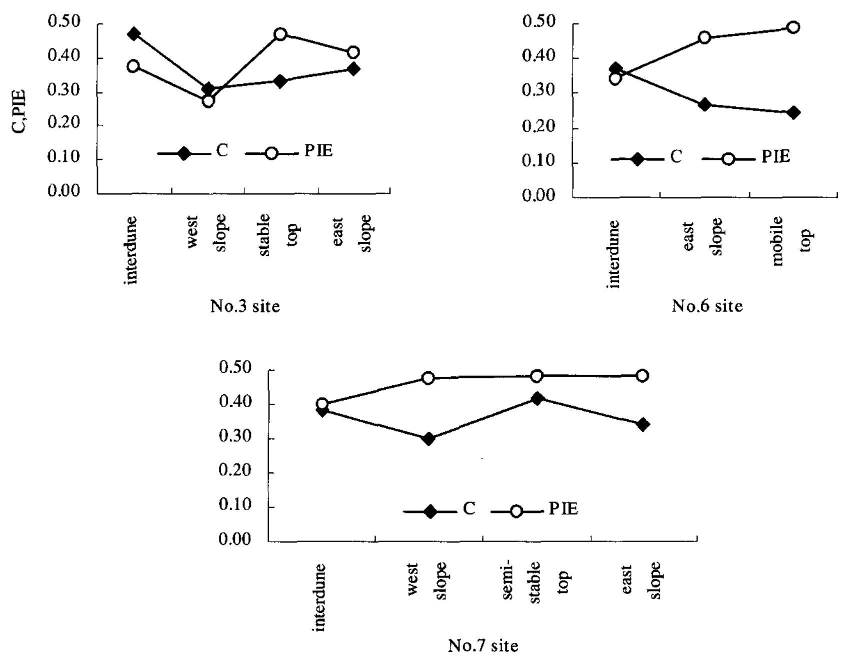



Figure 2 Diversity indices of plant communities in different geomorphologic environments of Gurbantunggut Desert

diversity on the tops of stable dunes was evidently higher than their two slopes. Generally, the plant community diversity indices varied with the changes of micro-landform from the slopes to the tops of dunes. However, within this there were some inconsistencies, such as for PIE values of the vegetation on the tops of semi-stable dunes.

The study shows that within the large-scale climate conditions and characteristics of geomorphologic form, soil is an important eco-environmental factor and the heterogeneity of its physical and chemical properties directly impacted on the patterns of vegetation distribution. This agrees with the findings of others (Bolling *et al.*, 2000; Li *et al.*, 2001; Shen, 2002; Zhang *et al.*, 2002). The most intuitive representation comes from the community diversity indices, such as PIE and C varying with the spatial positions of quadrats (Figure 3). The soil physical and chemical properties measured in samples from the study area included soil nutrients (organic matter, N, P and K), soil salts ($Ca^{2+}$, $Mg^{2+}$, $Na^{+}$, $K^{+}$, $Cl^{-}$, $SO_4^{2-}$, $HCO_3^{-}$, $CO_3^{2-}$), soil moisture and pH. Because these micro-ecoenvironmental factors were found to impact on plant community diversity, they were assembled into fewer factors by PCA in order to carry out research. Two groups of factors, $F_1$ and $F_2$, were chosen. Soil nutrients, soil salts, soil moisture and pH make up the positive indices of $F_1$, and the height above sea level is the negative index of $F_1$. The soil physical and chemical properties were divided into two groups when being assembled into $F_2$. Soil organic matter, TN, TK and soil moisture in the top 0-30 cm were the positive indices of $F_2$ and TP, T-salts and soil moisture in the 30-60 cm soil layer the negative ones (Figure 4). The interrelationship between the ecoenvironmental factors of height above sea level, the soil physical and chemical properties and the constructed factors of $F_1$ and $F_2$ can be expressed using the following function formulas:

$$F_1 = 0.151OM+0.147TN+0.157TP+0.095TK+0.117pH+0.16TS+0.157SM_{30}+0.15SM_{60}-0.041AL$$

$$F_2 = 0.098OM+0.153TN-0.198TP+0.43TK-0.015pH-0.155TS+0.085SM_{30}-0.141SM_{60}+0.69AL$$

According to the formulas, the values of $F_1$ and $F_2$ were correspondingly gained from every sampling site, and the spatial variation curves of $F_1$ and $F_2$ adequately confirm the heterogeneity

Table 1 Characteristics of the vegetation communities in the study area

| Sites | Latitude Others | Geomorphologic landscape | Communities | Woody plants: Dominant species | Woody plants: Num. | Woody plants: Cover (%) | Herbaceous plants: Dominant species | Herbaceous plants: Num. | Herbaceous plants: Cover (%) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 45°41'52.1"N | Desert plain of stepifilication | *Ceratoides lateens-Salsola arbuscula-Stipa glareosa* | *Ceratoides lateens, Salsola arbuscula et al.* | 3 | 21.78 | *Carex physode, Stipa glareosa et al.* | 7 | 94.40 |
| 2 | 45°36'21.3"N | Depression | *H.ammodendron-Anabasis brevifolia*–annual halophytes | *H.ammodendron, Anabasis brevifolia* | 2 | 27.95 | *Halogeton arachnoideus, Salsola brachiata et al.* | 10 | 66.23 |
| 3-1 | 45°34'04.2"N Longitudinal dune from south to north | Interdune land | *Ephedra distachya* -annunal plants | *E. distachya, Calligonum leucocladum* | 2 | 15.42 | *Erodium oxyrrhynchum, Alyssum linifolium, Ceratocarpus arenarius et al.* | 4 | 37.55 |
| 3-2 | | West slope of 17° | *H. persicum-E. distachya* -herb plants | *E. distachya, H. persicum, C. leucocladum* | 3 | 21.59 | *C. arenarius, C. physode, E. oxyrrhynchum et al.* | 9 | 32.68 |
| 3-3 | | Stable top | *H. persicum-C. leucocladum* -herb plants | *H. persicum, C. leucocladum et al.* | 2 | 29.28 | *C. physode, S. glareosa, C. arenarius et al.* | 9 | 42.15 |
| 3-4 | | East slope of 19° | *H. persicum-C. leucocladum* -herb plants | *C. leucocladum, H. persicum* | 2 | 33.30 | *C. physode, S. glareosa, C. arenarius et al.* | 10 | 147.75 |
| 4 | 45°05'32.4"N | Slight slope of interdune land | *H. persicum-E. distachya*-ephemeral plants | *E. distachya, H. persicum* | 2 | 5.44 | *E. oxyrrhynchum, Torularia torulosa et al.* | 14 | 36.42 |
| 5-1 | 44°57'02.2"N Complex | West slope of 14~16° | *Seriphidium santolina-E. distachya*-ephemeral plants | *S. santolina, E. distachya et al.* | 5 | 19.27 | *C. physode et al.* | 23 | 62.90 |
| 5-2 | longitudinal dunes | East slope of 19~20° | *E. distachya-S. santolina* -ephemeral plants | *E. distachya, S. santolina , C. leucocladum* | 3 | 42.18 | *C. physode et al.* | 12 | 77.36 |
| 6-1 | 44°40'46.5"N ephemeral and ephemeroid | Interdune land | *E. distachya-C. leucocladum*-ephemeral plants | *C. leucocladum, E. distachya* | 2 | 9.77 | *C. physode, E. oxyrrhynchum et al.* | 9 | 45.66 |
| 6-2 | plants | East slope of 24° | *H. persicum-E. distachya-C. leucocladum*-ephemeral plants | *H. persicum, E. distachya et al.* | 4 | 21.53 | *C. physode, E. oxyrrhynchum et al.* | 17 | 86.21 |
| 6-3 | | Mobile top | *H. persicum-Artemisia arenaria*-ephemeral plants | *A. arenaria, H. persicum et al.* | 4 | 27.48 | *C. physode et al.* | 22 | 100.40 |
| 7-1 | 44°30'17.4"N | Interdune land | *H. persicum-E. distachya*-ephemeral plants | *E. distachya , H. persicum et al.* | 4 | 17.39 | *E. oxyrrhynchum, C. physode, Hyalea pulchella et al.* | 6 | 31.76 |
| 7-2 | | East slope of 28~34° | *H. persicum*-ephemeral plants | *H. persicum, E. distachya et al.* | 3 | 2.15 | *H. pulchella, Alyssum linifolium et al.* | 10 | 75.34 |
| 7-3 | | Semi-stable top | *H. persicum-C. leucocladum*-ephemeral plants | *H. persicum, A. arenaria et al.* | 4 | 30.69 | *C. physode, E. oxyrrhynchum et al.* | 5 | 25.46 |
| 7-4 | | West slope of 18~20° | *H. persicum-C. leucocladum - E. distachya* - ephemeral plants | *E. distachya , H. persicum , C. leucocladum et al.* | 4 | 6.08 | *E. oxyrrhynchum, C. physode, H. pulchella et al.* | 6 | 14.94 |
| 8-1 | 44°26'50.1"N Checkerboard -shaped dunes | Interdune land | *E. distachya-Seriphidium terrae-albae*-ephemeral plants | *E. distachya, S. terrae-albae* | 2 | 26.18 | *C. physode et al.* | 9 | 85.22 |
| 8-2 | | South slope | *H. persicum-E. distachya*-ephemeral plants | *E. distachya , H. persicum et al.* | 4 | 34.36 | *C. physode, Nepeta micrantha et al.* | 7 | 109.19 |
| 8-3 | | Stable top | *H. persicum* - ephemeral plants | *H. persicum , C. leucocladum* | 2 | 29.55 | *C. physode et al.* | 12 | 45.35 |
| 9 | 44°17'33.1"N | Plain | *H.ammodendron-Reaumuria soongorica*-annual halophytes | *R. soongorica-H. ammodendron* | 2 | 87.14 | *Petrosmonia sibirica, Salsola collina et al.* | 3 | 39.09 |
| 10-1 | 44°16'39.0"N | Interdune land | *E. distachya*-ephemeral plants | *E. distachya, C. leucocladum et al.* | 3 | 0.94 | *E. oxyrrhynchum, H. pulchella et al.* | 8 | 62.72 |
| 10-2 | | West slope of 17° | *H. persicum-E. distachya* - ephemeral plants | *H. persicum, E. distachya et al.* | 3 | 10.94 | *E. oxyrrhynchum, C. physode et al.* | 9 | 59.12 |
| 10-3 | | Semi-stable top | *H. persicum-Seriphidium santolina*-ephemeral plants | *H. persicum, S. santolina et al.* | 3 | 17.09 | *C. physode, E. oxyrrhynchum, Aristida Pennata* | 9 | 100.04 |
| 10-4 | | East slope of 22° | *H. persicum-S. santolina*-ephemeral plants | *S. santolina, H. persicum et al.* | 4 | 1.80 | *Corispermum lehmannianum, C. physode, E. oxyrrhynchum et al.* | 14 | 45.26 |
| 11 | 44°14'04.4"N | Plain | *H. ammodendron-R. soongorica* | *H. ammodendron, R. soongorica* | 2 | 32.34 | | 0 | |

of soil physical and chemical properties in the study area (Figure 5). CA analysis showed the impact of the constructed factors $F_1$ and $F_2$ on the dominance and diversity of plant communities. The diversity of herb synusia (PIEherb) was restricted by $F_1$, with a strong negative correlation (Table 2). The cause for this is thought to be that the aeolian sandy soil is very low in nutrients, and a proper improvement of soil nutrient and soil moisture in the surface layer increases the number of dominant species for those shallow-rooted plants. Then, the increase in soil salt and pH favoured the survival of saline-alkaline-tolerant plants over non-tolerant plants. At last, the competition between the species restricted the increase of their numbers. So, $F_1$ can be viewed as a limiting factor to the diversity of herb synusia within plant communities, with the regression relationship of PIEherb = $-0.0287F_1^3+0.0662F_1^2 - 0.0257F_1+0.5774$. It should explain that the edificators of herb synusia, relative to co-edificators, did not show an absolute dominance in the varying range of soil physical and chemical properties, except for a few quadrats. Thus, the relationship between dominance C and $F_1$ is not of significance. The impact of $F_1$ on the dominance and diversity of tree and shrub synusia is not clear, which farther reflects the characteristics of Gurbantunggut Desert's vegetation composition. That is, the vegetation of the desert consists of psammophyte and drought-tolerant *Chenopodiaceae* plants as edificators, but the composition of their communities and associations is poor and their structure flat (Chen *et al.*, 2001; Zhang, 2002). As Table 1 shows, the species of edificators varies with the spatial changes in macro-ecoenvironment. However, the increase and decrease of tree and shrub species is not large, with the species of 2-4 (occasionally 5). So, the heterogeneity of the microhabitats, based on soil physical and chemical properties, is not a clear cause of the species diversity of the synusia.

The authors have discussed the significance of constructed factor, $F_2$ of soil physical

Table 2 Correlation coefficients of the eco-environmental factors and vegetation community parameters in the research area

| | Wood C | Herb C | Wood PIE | Herb PIE | OM | TN | TP | TK |
|---|---|---|---|---|---|---|---|---|
| Wood C | 1.000 | .213 | -.377 | .004 | .067 | .104 | .038 | .056 |
| Herb C | .213 | 1.000 | -.135 | -.236 | -.104 | -.119 | -.189 | -.372 |
| Wood PIE | -.377 | -.135 | 1.000 | -.232 | .117 | .193 | .160 | .048 |
| Herb PIE | .004 | -.236 | -.232 | 1.000 | -.543** | -.610** | -.534** | -.178 |
| OM | .067 | -.104 | .117 | -.543** | 1.000 | .880** | .826** | .584** |
| TN | .104 | -.119 | .193 | -.610** | .880** | 1.000 | .812** | .619** |
| TP | .038 | -.189 | .160 | -.534** | .826** | .812** | 1.000 | .354 |
| TK | .056 | -.372 | .048 | -.178 | .584** | .619** | .354 | 1.000 |
| pH | .085 | -.172 | -.091 | -.310 | .642** | .566** | .550** | .575** |
| TS | .032 | -.154 | .284 | -.490* | .842** | .804** | .960** | .420* |
| $SM_{30}$ | .157 | -.215 | .262 | -.477* | .861** | .877** | .820** | .700** |
| $SM_{60}$ | .056 | -.194 | .361 | -.535** | .723** | .718** | .884** | .377 |
| AL | -.106 | .114 | -.062 | .029 | -.011 | .041 | -.262 | .168 |
| $F_1$ | .089 | -.210 | .208 | -.543** | .919** | .905** | .925** | .624** |
| $F_2$ | -.035 | -.037 | -.084 | .019 | .142 | .212 | -.234 | .560** |

| | pH | TS | $SM_{0-30}$ cm | $SM_{30-60}$ cm | AL | $F_1$ | $F_2$ |
|---|---|---|---|---|---|---|---|
| Wood C | .085 | .032 | .157 | .056 | -.106 | .089 | -.035 |
| Herb C | -.172 | -.154 | -.215 | -.194 | .114 | -.210 | -.037 |
| Wood PIE | -.091 | .284 | .262 | .361 | -.062 | .208 | -.084 |
| Herb PIE | -.310 | -.490* | -.477* | -.535** | .029 | -.543** | .019 |
| OM | .642** | .842** | .861** | .723** | -.011 | .919** | .142 |
| TN | .566** | .804** | .877** | .718** | .041 | .905** | .212 |
| TP | .550** | .960** | .820** | .884** | -.262 | .925** | -.234 |
| TK | .575** | .420* | .700** | .377 | .168 | .624** | .560** |
| pH | 1.000 | .534** | .623** | .491* | -.259 | .706** | -.005 |
| TS | .534** | 1.000 | .883** | .918** | -.227 | .944** | -.179 |
| $SM_{30}$ | .623** | .883** | 1.000 | .868** | -.066 | .958** | .127 |
| $SM_{60}$ | .491* | .918** | .868** | 1.000 | -.162 | .887** | -.162 |
| AL | -.259 | -.227 | -.066 | -.162 | 1.000 | -.163 | .876** |
| $F_1$ | .706** | .944** | .958** | .887** | -.163 | 1.000 | .000 |
| $F_2$ | -.005 | -.179 | .127 | -.162 | .876** | .000 | 1.000 |

**P>0.01; *P>0.05; Wood includes tree and shrub.

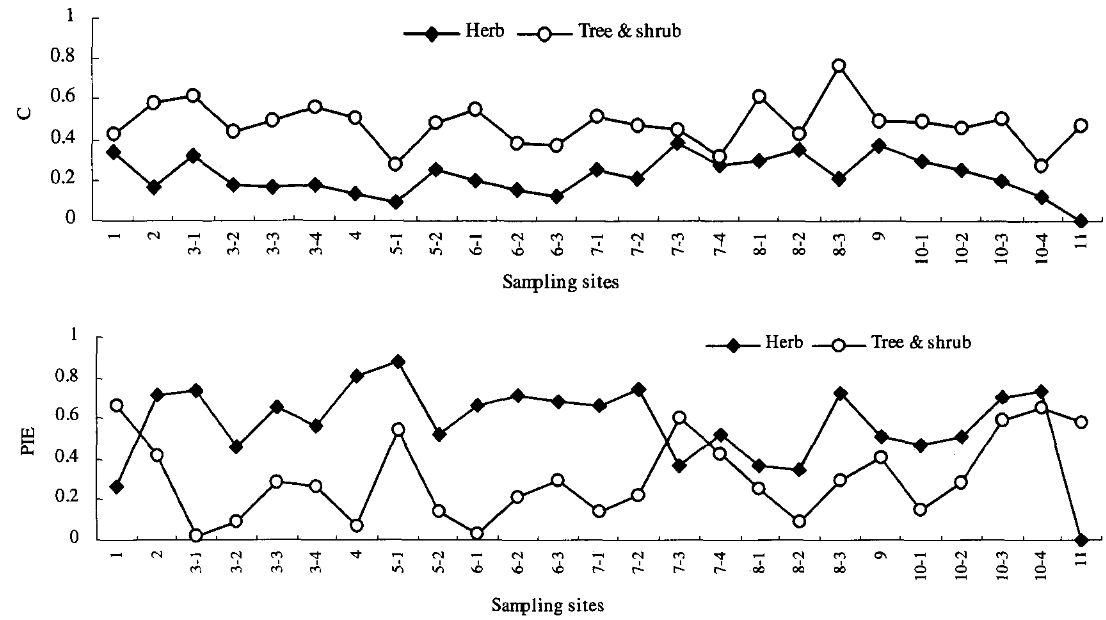



Figure 3 Spatial variation of diversity indices (PIE and C) for plant communities of Gurbantunggut Desert

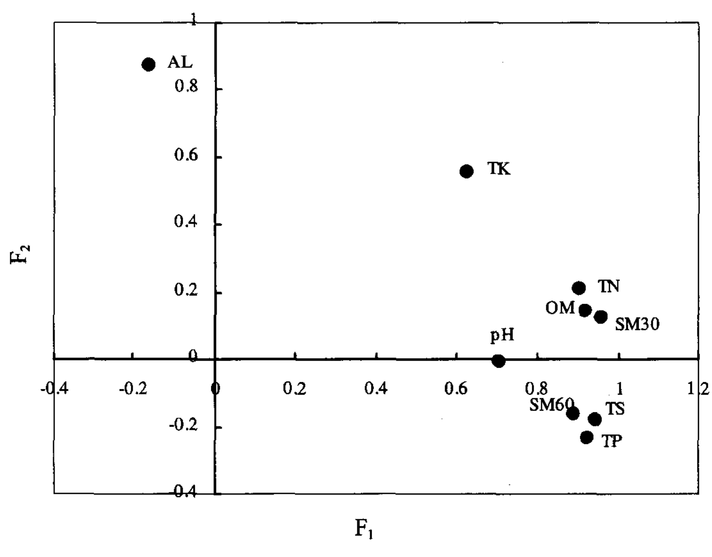



Figure 4 Distribution of soil physical and chemical indices on the principal components of Gurbantunggut Desert

and chemical properties, and thought that $F_2$ is a potential impacting factor on the diversity of plant communities. This was their findings when studying the diversity of plant communities of the marginal zone of Gurbantunggut Desert, Agricultural Development Area of Kelamayi (Karamay) (Qian *et al*., 2003). As mentioned above, soil physical and chemical properties represented the positive and negative differentiation on the $F_2$ axis (Figure 4). Thus, an antagonistic interaction occurs between TP, TS and deep soil moisture on the one hand and OM, TN and shallow soil moisture on the other hand, forming a relatively stable equilibrium. However, the equilibrium of the desert ecoenvironment is very fragile. Once the composition of $F_2$ changes, the relative equilibrium between the microhabitats of aeolian sandy soil and the plant communities is likely to be damaged. Thus, the impact of $F_2$ on the diversity of plant communities should not be neglected.

At last, we must mention the impact of human activities on plant community structure. Overgrazing has degraded the north desert pasture of Gurbantunggut Desert. Random cutting and digging has destroyed *Popular euphratica* and *Haloxylon ammodendron* forest and has brought

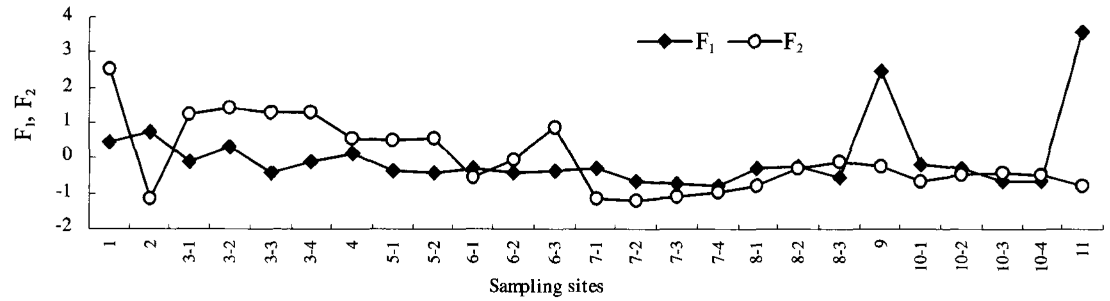



Figure 5 Variational curves for principal components ($F_1$ and $F_2$) of soil physical and chemical properties of Gurbantunggut Desert

*Cistanche deserticola* to the verge of local extinction in the southern margin of Gurbantunggut Desert (Zhang, 2002). So, unsustainable human economic activities have made the diversity of plant communities fall greatly.

## 4 Conclusion

The plant species recorded in the study area represent one third of the species found in the Gurbantunggut Desert. These plants in their various communities are distributed very widely across the desert, and such desert vegetation has great significance and interaction with the landscape. The characteristics of plant distributions in the study area well represent the vegetation patterns over the whole Gurbantunggut Desert. The distribution of vegetation communities relate to the spatial variation of macro-ecoenvironment, such as local climate and landform. The aeolian sandy soil's physical and chemical properties (including soil nutrient, soil moisture, soil salt, and pH) that indicate microhabitat heterogeneity significantly impacted on the species composition of herb synusia and community structure. As a result, the diversity indices fell with increases in the composite constructed factor $F_1$ of microhabitats. Principal Component Analysis (PCA) and Correlation Analysis (CA) revealed the antagonistic actions of microhabitats on plant community pattern that is likely to keep the eco-distribution of vegetation in a state of temporary equilibrium. Further disturbance of the fragile eco-equilibrium of the Gurbantunggut Desert -- by human or natural factors -- is likely to trigger changes to the components of the $F_2$ factor (microhabitats mentioned above) that will lead to impacts and changes to the vegetation patterns of the Gurbantunggut Desert.

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