http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 11 (3): 366-372, 2008
ISSN 1028-8880

The Use of Principal Component Analysis in Studying Physical, Chemical and Biological Soil Properties in Southern Caspian Forests (North of Iran)

[1]Yahya Kooch, [1]Hamid Jalilvand, [2]Mohammad Ali Bahmanyar and [1]Mohammad Reza Pormajidian
[1]Faculty of Natural Resources,
[2]Faculty of Agricultural Sciences, University of Mazandaran, Iran

Abstract: This research was conducted in Khanikan forests located in lowland of Mazandaran province (North of Iran). Eighteen profiles were dug and several chemical, physical and biological soil properties were investigated. The soil properties evaluated were soil pH, bulk density, saturation moisture content, electrical conductivity, organic carbon, total nitrogen, cation exchangeable capacity, available phosphorous, soil texture, calcium carbonate content, number and biomass of earthworms, litter carbon and litter nitrogen. Principal Component Analysis (PCA) was used to identify the variation of soil properties. PCA, a technique which reduces the dimensionality of multivariate data by removing Interco relations among variables, has a number of useful applications in forest researches. The results showed significant relationships between some soil factors with PC_1 and PC_2 axes, also, among different soil factors, the distribution of forest types was most strongly controlled with some soil characteristics such as acidity, bulk density, texture, phosphorous, organic carbon, total nitrogen and cation exchangeable capacity.

Key words: Multivariate analysis method, principal component analysis, soil properties, forest

INTRODUCTION

The accepting or rejecting the null hypothesis, judgments must be made about the extent of differences between dependent variables or whether the strength of any relationship between the X and Y is sufficient to merit the rejection of the null hypothesis. These decisions are more easily made when quantitative data is available. Statistical analysis allows such judgments to be made in a quantifiable way (Wilson *et al*., 2001).

Statistics provides a set of objective procedures to efficiently summarize the data and compare the values. Where the results of analysis suggest that the null hypothesis should be rejected, the use of statistics allows the reliability of this decision to assess. This is the great value of statistics. In an ideal world, predictions would be tested and a hypothesis accepted or rejected with complete certainly (Austin and Noy-Meir, 1971). Unfortunately, in biology, ecology and environmental sciences it is rarely possible to formulate the null hypothesis so it can be accepted or rejected in a simple yes or no manner. A decision has to be made on the balance of probability that a decision is correct, allowing choices to be made in an informed manner (Mesdaghi, 2001).

Since variations of soil properties are high and soil characteristics relate to several variables, multivariate analysis should be more useful than other univariate statistic methods. Multivariate analysis methods assume that several random variables have interred relation between each other and that they are important for researcher (Moghadam, 2000). Classification and ordination are two main branches of multivariate analysis and in this study as ordination method were used. In general, ordination is the ordering of objects along axes according to their resemblance (Mc Cune and Mefford, 1999). The major objective is to achieve an effective data reduction, expressing many dimensions. One of the most famous ordination methods is Principal Component Analysis (PCA) (Mesdaghi, 2001, 2005).

PCA is the basic Eigen-analysis technique and was first introduced by Pearson used in ecology (Mesdaghi, 2001). It maximize the variance explained by each successive axis. Although it has severe faults with many community data sets, it is probably the best technique to use when a data set approximates multivariate normality and variables have linear relationships. This method was gradually introduced as an applied multivariate analysis method in ecology after 1966 and is one widespread method to ordinate data in ecology (Pourbabaei, 2004). Although using this method for ordination of floristic data meets some limitations (Mesdaghi, 2001), results of PCA on site data collected with floristic data can be valuable (Goldsmith, 1973).

Corresponding Author: Yahya Kooch, Department of Forestry, Faculty of Natural Resources, University of Mazandaran, P.O. Box 737, Badeleh, Sari, Iran Tel: 0151-2445411 Fax: 0152-4222982

Several studies investigating the relationship between environmental factors and vegetation have been conducted using PCA in Iran (Zahedi Amiri, 1998; Zahedi Amiri and Mohammadi Limayee, 2002; Hassanzad Navroodi *et al*., 2004, Salehi, 2004; Taleshi, 2004; Mahmoodi *et al*., 2005; Salehi and Zahedi Amiri, 2005; Salehi *et al*., 2005).

Also, using of principal component analysis are well studied and results for models have been reported by Schoenholtz *et al*. (2000), Ewald (2000), Hedman *et al*. (2000), Wilson *et al*. (2001), Stendhal *et al*. (2002), Phillips *et al*. (2002), Crowley *et al*. (2003), Lyon and Gross (2005), Ajbilou *et al*. (2006) and Corney *et al*. (2006). In this study we used PCA as valuable method to define the most significant and important soil properties in differentiation of forest types in lowland forest of khanikan chaloose (North of Iran).

MATERIALS AND METHODS

Study site location and description: Khanikan forests are located in the lowland and midland of Mazandaran province in North of Iran with the area of 2807 ha^{-1} (Between 36° 33′ 15″, 36° 37′ 45″ latitude and between 51° 23′ 45″, 51° 27′ 45″ longitude). The maximum elevation is 1400 m and the minimum elevation is 50 m. Minimum temperature in December (7.5°C) and the highest temperature in June (24.6°C) are recorded, respectively. Mean annual precipitation of the study area were from 237.6 to 47.5 mm at the Noushahr city metrological station, which is 10 km far from the study area. This research was performed in mid-summer of 2006.

Soil sampling and analysis method: In lowland region 268.7 ha^{-1} of this forest was selected. For investigation of tree and shrub covers sixty quadrate (20×20 m AR.) (Hedman *et al*., 2000; Grant and Loneragan, 2001; Mesdaghi, 2001) and sub quadrate (1 m^2 AR.) in each quadrate for investigation of herbaceous covers (Mesdaghi, 2001), were taken by randomized-systematic method. Considering variation of vegetation and environmental factors, floristic list and canopy cover percentage were determined in each quadrate. Vegetation cover data were recorded using ordinal scale of Van-der-Marel (1979). Soil samples were selected from organic horizon (litter layer) and mineral layers (0-10, 10-20 and 20-30 cm).

Soil pH, bulk density, saturation moisture content, electrical conductivity, organic carbon, total nitrogen, cation exchangeable capacity, available phosphorous, soil texture, calcium carbonate content, number and biomass of earthworms, litter carbon and litter nitrogen were determined. Slope, elevation and aspect were recorded for each plot using a clinometers, altimeter and compass, respectively.

Data vegetation for each species in all of the sampling plots and the total vegetation for all of the species within each plot were calculated. Two-way indicator species analysis method (TWINSPAN) was used for classification of vegetation groups to determine forest types (Hill *et al*., 1976). For above mentioned multivariate analysis PC-ORD program version 3.17 was used. Comparing of means of environmental factors amongst forest types and also study of inter-relationships between these variables was evaluated by one way ANOVA (Analysis of ANOVA) method in SAS of statistical program.

PCA is the ordination technique that constructs the theoretical variable that minimizes the total residual sum of squares after fitting straight lines to the species data. PCA does so by choosing the best values for the sites. The apply PCA; data standardization is necessary if we are analyzing variables that are measured in different units. Also, species with high variance, often the abundant ones, therefore dominate the PCA solution, whereas species with low variance, often the rate ones, have only minor influence on the solution. These may be reasons for applying the standardized PCA, in which all species receive equal weight (Jongman *et al*., 1995). Therefore, data was centered and standardized by standard deviation.

RESULTS

Distribution of soil properties and forest types by PCA axes: The Eigen values and proportion of variance explained by the axes are listed in Table 1. The proportion of the variance is simply the Eigen value for that axis divided by the total variance i.e., the sum of the diagonal of the cross-products matrix.

The soil properties and forest types occupied different regions of the diagram (Fig. 1). According to the Pearson and Kendall correlation coefficient among soil variables and between them and main axes of PCA. The correlation structure is used to position objects in the ordination space and objects close in the ordination space are generally more similar than objects distant in the ordination space (Mc Cune and Mefford, 1999).

Table 1: Percentage of variance and Eigen values of PCA axes

Axes	Eigen value	Percentage of variance
1	30.742	59.119
2	10.107	78.555
3	8.182	94.290
4	2.969	100.000

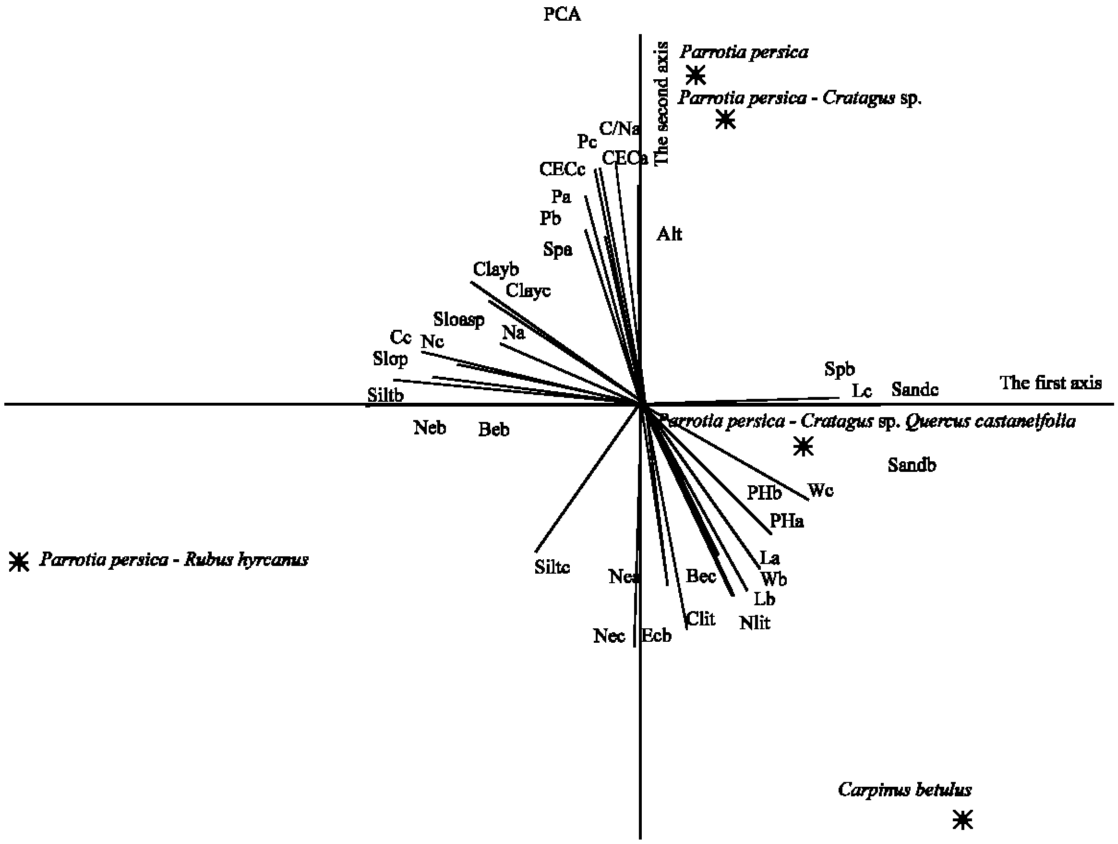

Fig. 1: Distribution of soil factors and forest types in the two first PCA axes

As shown in Table 1, the first axis of PCA is the most important to explain variance across the variables (soil factors). The percentage of Eigen value for the first axis and second axis of PCA are about 90 and 89%, respectively. As mentioned before, the location of soil properties and forest types in different regions of PCA axes is on the basis of correlation coefficient between variables, therefore the location of the variables in the diagram is significant and important. For example, forest types that occupied a specific region and are close to each other have several similar characteristics between each other and consequently the correlation coefficient between those characteristics should be high. On the other hand, the characteristics of profiles occupying opposite places in the diagram, for example opposite direction of an axis show distinct variations.

Eigen vectors and correlation coefficients between soil variables and the PCA axes: The values of the Eigen vector for soil variables and the axes of PCA are shown in Table 2. Eigen vectors contain set of scores that show the weight of each variable (soil variables) on each axis of PCA. Eigen vectors very between -1 to +1 and if the value of the Eigen vector for a specific variable is close to absolute of 1, it is more important to weight on the axes (Mesdaghi, 2001). As shown in Table 2, the Eigen vectors for content of clay, nitrogen, bulk density and acidity in second layer and acidity in one and third layers for the first axis and the value of clay, silt, electrical conductivity, nitrogen in one layer, phosphorus, carbon to nitrogen ratio in second layer and carbon to nitrogen ratio in third layer for second axis, are higher compared to the Eigen vectors of other variables. The last mentioned subject showed that these variables play a more important role to explain the first and second axes of variation.

These coefficients express the linear (Pearson's r) and rank (Kendall's tau) relationships between the PCA scores and the individual variables used to construct the axes. The table of correlation coefficient can be quite helpful in providing a quick interpretation of the ordination. As shown in Table 3, acidity of one layer ($r = 0.999$), acidity of second layer ($r = 0.977$), acidity of third layer ($r = 0.970$), bulk density of third layer ($r = 0.915$), nitrogen of litter ($r = 0.940$), content sand of second layer ($r = 0.911$), lime of one layer ($r = 0.920$), lime of second layer ($r = 0.935$) have a negative relationship to the first

Table 2: Eigen vectors of soil variables for the first six PCA axes

	Axes							Axes					
Variables	1	2	3	4	5	6	Variables	1	2	3	4	5	6
Nea	-0.10	-0.16	0.09	0.33	-0.12	-0.01	Nb	0.13	-0.12	0.13	-0.20	-0.04	0.09
Neb	0.11	0.06	0.25	0.03	0.02	0.02	Nc	0.15	0.11	0.11	0.04	0.10	0.10
Nec	-0.09	0.03	0.29	0.00	0.12	-0.24	C/Nlit	0.16	-0.12	-0.04	0.02	-0.11	0.08
Bea	-0.04	0.17	-0.10	0.42	-0.08	-0.00	C/Na	0.11	-0.00	-0.26	0.02	-0.00	0.07
Beb	0.12	0.06	0.24	-0.01	0.02	-0.04	C/Nb	0.11	-0.23	-0.01	0.00	0.05	-0.04
Bec	-0.15	0.08	0.16	-0.05	0.11	-0.11	C/Nc	0.02	-0.29	0.02	-0.15	0.17	0.01
PHa	-0.18	0.01	0.00	-0.00	-0.01	0.20	CECa	0.14	0.15	-0.09	-0.09	-0.00	-0.10
PHb	-0.17	0.06	0.03	-0.00	0.17	0.25	CECb	0.07	0.18	0.03	-0.39	0.02	-0.07
PHc	-0.17	0.09	0.04	-0.03	0.13	-0.20	CECc	0.16	0.05	-0.09	-0.11	0.00	0.03
Wa	-0.10	0.20	0.16	-0.05	-0.01	-0.07	Pa	0.12	0.18	-0.12	0.11	-0.08	0.03
Wb	-0.17	-0.06	0.03	0.02	0.07	0.14	Pb	0.12	0.22	-0.05	-0.04	0.00	-0.07
Wc	-0.16	0.02	0.02	-0.22	-0.34	0.00	Pc	0.11	0.18	-0.16	0.05	-0.06	-0.04
Spa	0.16	-0.09	-0.12	-0.00	-0.04	-0.12	Sana	-0.15	0.15	-0.03	-0.11	-0.21	-0.17
Spb	-0.10	0.01	-0.28	0.04	0.19	0.10	Sandb	-0.16	-0.05	-0.11	-0.09	-0.02	-0.08
Spc	0.17	-0.06	-0.00	-0.05	0.05	-0.03	Sandc	-0.13	-0.05	-0.22	-0.03	-0.04	0.01
Eca	-0.09	0.25	-0.00	0.15	-0.07	0.08	Silta	0.13	-0.20	0.04	0.09	-0.03	-0.07
Ecb	-0.13	0.05	0.21	0.06	0.03	-0.11	Siltb	0.13	-0.03	0.19	0.17	-0.05	0.04
Ecc	-0.14	0.15	0.09	-0.10	0.00	0.02	Siltc	-0.02	0.07	0.32	0.12	0.10	0.03
Clit	-0.12	-0.12	0.17	-0.18	-0.65	0.10	Claya	0.06	0.28	-0.03	0.07	-0.29	0.05
Ca	0.17	-0.04	-0.00	-0.10	-0.02	-0.05	Clayb	0.17	0.04	0.01	0.07	-0.05	0.29
Cb	0.13	-0.15	0.12	-0.16	-0.04	0.02	Clayc	0.17	0.01	0.04	-0.02	0.07	-0.02
Cc	0.15	0.05	0.16	-0.04	0.03	0.18	La	-0.16	-0.12	0.00	0.02	0.03	0.01
Nlit	-0.16	0.06	0.08	-0.06	0.12	-0.19	Lb	-0.16	-0.02	0.10	-0.11	0.08	0.60
Na	0.17	-0.05	0.07	-0.06	-0.08	-0.13	Lc	-0.11	0.15	-0.16	-0.20	0.06	0.07

a, b, c cods = 0-10, 10-20, 20-30 layers, respectively

Table 3: Pearson and Kendall correlation between soil variables and PCA axes

	1		2		3			1		2		3	
Axes	r	tau	r	tau	r	tau	Axes	r	tau	r	tau	r	tau
Nea	-0.57	-0.52	-0.51	-0.52	0.26	0.10	Nb	0.74	0.52	-0.40	-0.10	0.38	0.31
Neb	0.64	0.83	0.19	-0.12	0.73	0.59	Nc	0.85	1.00	0.37	0.00	0.34	0.20
Nec	-0.51	0.00	0.09	-0.20	0.85	0.80	C/Nlit	0.91	0.40	-0.39	-0.60	-0.12	0.00
Bea	-0.26	-0.20	0.54	0.40	-0.31	-0.20	C/Na	0.66	0.20	-0.03	0.40	-0.74	-0.60
Beb	0.66	0.83	0.21	-0.12	0.71	0.59	C/Nb	0.66	0.40	-0.749	-0.60	-0.03	0.00
Bec	-0.84	0.20	0.27	0.00	0.45	0.60	C/Nc	0.15	0.00	-0.949	-0.60	0.07	0.00
PHa	-0.99	-0.80	0.03	0.20	0.00	-0.40	CECa	0.80	0.60	0.50	0.40	-0.27	-0.20
PHb	-0.97	-0.60	0.19	0.00	0.09	-0.20	CECb	0.40	0.60	0.60	0.40	0.08	0.20
PHc	-0.94	-0.40	0.30	0.60	0.11	0.00	CECc	0.92	0.60	0.17	0.40	-0.27	-0.20
Wa	-0.58	0.20	0.65	0.00	0.46	0.60	Pa	0.70	0.40	0.58	0.60	-0.35	-0.40
Wb	-0.97	-0.80	-0.21	-0.20	0.10	0.00	Pb	0.68	0.40	0.70	0.60	-0.15	0.00
Wc	-0.91	-0.60	0.07	0.00	0.06	0.20	Pc	0.65	0.40	0.58	0.60	-0.46	-0.40
Spa	0.89	0.00	-0.29	-0.20	-0.34	-0.40	Sana	-0.83	-0.60	0.49	0.40	-0.10	-0.20
Spb	-0.58	-0.60	0.03	0.40	-0.80	-0.60	Sandb	-0.911	-1.00	-0.17	0.00	-0.34	-0.20
Spc	0.97	0.60	-0.21	0.00	-0.02	0.20	Sandc	-0.73	-1.00	-0.18	0.00	-0.65	-0.20
Eca	-0.52	-0.20	0.81	0.40	-0.01	0.20	Silta	0.74	0.40	-0.63	-0.60	0.12	0.00
Ecb	-0.74	-0.31	0.18	-1.00	0.62	0.31	Siltb	0.77	0.80	-0.10	-0.20	0.54	0.40
Ecc	-0.81	-0.31	0.48	0.52	0.26	0.10	Siltc	-0.12	0.40	0.24	-0.20	0.93	0.80
Clit	-0.71	-0.52	-0.39	-0.52	0.49	0.31	Claya	0.38	0.20	0.90	0.80	-0.10	-0.20
Ca	0.97	0.60	-0.14	0.00	-0.01	0.20	Clayb	0.98	1.22	0.13	0.00	0.04	0.20
Cb	0.74	0.60	-0.48	0.00	0.35	0.20	Clayc	0.99	1.00	0.04	0.00	0.12	0.20
Cc	0.85	1.00	0.16	0.00	0.48	0.20	La	-0.92	-0.80	-0.38	-0.20	0.02	0.00
Nlit	-0.94	-0.40	0.20	0.60	0.24	0.00	Lb	-0.93	-0.60	-0.07	-0.40	0.28	0.20
Na	0.95	0.80	-0.16	-0.20	0.21	0.40	Lc	-0.64	-0.60	0.48	0.40	-0.46	-0.20

r = Linear (Pearson's r) correlation coefficient tau = Rank (Kendall's tau) correlation coefficient

axis of PCA. Saturation moisture (r = 0.972), percentage of organic carbon (r = 0.973), content of nitrogen (r = 0.956), carbon to nitrogen ratio of litter (r = 0.910), cation exchangeable capacity of third layer (r = 0.926), content of clay of second layer (r = 0.956), content of clay of third layer (r = 0.991) are positively correlated to the first axis of PCA. In relation to the second axis of PCA, it is negatively correlated to the carbon to nitrogen ratio in third layer (r = 0.949) and positively correlated to content of clay in one layer (r = 0.909) (Table 3).

Forest types and relationships between them and soil properties: The result of TWINSPAN method determined five main tree groups. We used these groups as forest

Table 4: Mean of soil chemical and physical properties for forest types in study area

Soil properties	Depth (cm)	*Carpinus betulus*	*Parrotia persica*	*Parrotia persica-Ruscus hyrcanus*	*Parrotia persica-Cratagus* sp.	*Parrotia persica-Cratagus* sp.-*Quercus castanifolia*
pH	0-10	6.95	5.59	5.05	5.09	5.58
	10-20	7.18	5.56	5.06	5.03	5.25
	20-30	7.15	5.52	5.02	5.12	5.01
BD	0-10	1.26	0.80	0.90	0.83	0.45
	10-20	1.32	0.94	0.90	0.85	1.07
	20-30	1.35	0.98	0.89	1.05	1.02
Sp (%)	0-10	29.45	60.74	59.34	65.19	67.07
	10-20	64.90	67.87	53.12	58.76	63.45
	20-30	33.57	60.21	72.95	76.21	69.20
Ec (dS m^{-1})	0-10	0.87	0.85	0.71	0.65	0.52
	10-20	0.82	0.49	0.64	0.48	0.49
	20-30	0.80	0.45	0.41	0.45	0.29
C (%)	0-10	1.71	3.22	3.95	4.34	3.65
	10-20	1.64	1.69	2.94	2.99	2.88
	20-30	0.92	1.34	2.41	2.11	1.31
N (%)	0-10	0.15	0.24	0.35	0.34	0.29
	10-20	0.14	0.14	0.22	0.23	0.21
	20-30	0.08	0.14	0.20	0.17	0.10
C/N	0-10	10.06	13.35	11.44	12.57	12.56
	10-20	11.52	12.18	12.95	12.80	13.75
	20-30	10.74	9.89	11.04	11.41	13.08
CEC (ppm)	0-10	11.40	26.10	22.18	28.40	15.60
	10-20	20.70	21.50	21.60	28.64	17.20
	20-30	10.40	24.40	22.80	28.64	20.20
P (ppm)	0-10	3.51	20.92	14.62	15.65	6.71
	10-20	2.73	13.18	10.51	13.62	2.06
	20-30	2.02	17.63	10.00	13.47	4.86
Sand (%)	0-10	0.79	68.87	58.60	65.20	0.59
	10-20	0.86	68.75	49.80	61.20	73.50
	20-30	73.25	70.50	51.40	60.80	0.71
Silt (%)	0-10	8.50	16.31	27.60	20.95	30.00
	10-20	0.11	15.43	29.80	18.90	18.50
	20-30	22.25	12.93	26.40	15.70	12.87
Clay (%)	0-10	12.50	14.81	13.80	13.85	0.11
	10-20	00.30	15.81	20.40	17.90	12.50
	20-30	04.50	16.56	24.20	23.50	16.12
L (%)	0-10	10.25	5.00	4.20	3.60	0.80
	10-20	20.75	3.37	4.60	5.20	0.80
	20-30	07.75	7.00	3.20	6.30	4.50
Ne	0-10	0.05	0.25	0.40	0.00	0.50
	10-20	0.00	0.00	0.40	0.20	0.00
	20-30	1.50	0.25	1.20	0.60	0.50
Be (g)	0-10	0.07	0.13	0.06	0.00	0.02
	10-20	0.00	0.00	0.07	0.04	0.00
	20-30	0.99	0.13	0.30	0.18	0.05
Clit (%)	-	7.08	6.31	6.62	6.62	60.79
Nlit (%)	-	2.17	1.46	1.41	1.42	1.40
C/N lit	-	3.26	4.32	4.69	4.66	4.85

types to study relationships between them and soil properties. Relationships between some important soil properties and forest types have been displayed in Table 4.

DISCUSSION

Forests, as complex ecosystems, usually have ranges of soils with varying properties. Some of these soil properties are more important than the others and play an obvious role to distinguish the soils covering specific regions. Understanding of the segregated factors among several different soil properties is useful for forest management (Yau, 1965; Salehi and Zahedi Amiri, 2005). PC analysis is a useful data reduction technique which works by removing Interco relations among variables (components). By using PC analysis, not only is the number of comparisons between treatment means reduced, but the meaningfulness of these comparisons is enhanced. In this research, using of multivariate analysis obviously set apart differences of soil properties among soil profiles (Mesdaghi, 2001).

The results showed that in the study area, among different soil factors, the distribution of forest types was most strongly controlled with some soil characteristics such as acidity, bulk density, texture, phosphorous, organic carbon, total nitrogen and cation exchangeable capacity (Table 2). Result of principal component analysis showed, the first two principal components together accounted for 78.55% of the total variance in data set. Therefore, 59.11 and 19.43% variance were accounted for by the first and second principal components, respectively (Table 1).

The obtained result showed that the first axis has the most correlation with productively factors and the second axis has the most correlation with physical factors of soil. This result has been reported by many investigations (Zahedi Amiri and Mohammadi Limayee, 2002; Stendhal *et al*., 2002; Hassanzad Navroodi *et al*., 2004; Mahmoodi *et al*., 2005; Salehi *et al*., 2005). In humid and sub humid regions, the relation between species distribution and acidity gradient has been reported by many investigators (Oland *et al*., 1998; Ewald, 1999; Coker, 2000; Ewald, 2000; Phillips *et al*., 2002; Crowley, 2003; Taleshi, 2004).

Also, soil texture and bulk density controls distribution of plant species by affecting moisture availability, ventilation and distribution of plant roots. Soil texture is the most fundamental soil physical property controlling water, nutrient and oxygen exchange an uptake (Schoenholtz *et al*., 2000) and influences the growth and distribution of vegetation (Fisher and Binkley, 2000). Organic carbon and nitrogen are the effective factors in the differentiation of vegetation types (Zahedi Amiri and Mohammadi Limayee, 2002; Salehi *et al*., 2005). The role CEC and available phosphorous, as key elements in the distribution of plant species, is described by Zahedi Amiri and Mohammadi Limayee (2002).

On the other hand, although several environmental factors affect the rate of litter decomposition, the rate of litter fall is remarkably uniform among tree species growing under similar soil and climatic conditions (Fisher and Binkley, 2000). Finzi *et al*. (1998) showed that there were differences in the size and distribution of carbon and nitrogen pools at varying soil depth beneath six different tree species in temperature forests. Edwards *et al*. (1970) reported that the decomposition rate of beech leaves is lower than oak, elm, birch and ash leaves. Comparison of leaf decomposition rates among different plant species revealed that litter of *Carpinus orientalis* was decomposed more rapidly than *Quercus castanifolia* (Cornelissen, 1996). In the one forest type that dominant tree species was *Carpinus betulus*, thus, collection of climatic conditions and activity of earthworm (especially in the third layer) were effective in low and high content of carbon. Therefore, in the one forest type with *Carpinus betulus* dominant species, content of carbon was lower, presence and activity of earthworms were more visible, thus, decomposition of organic matter were higher (Table 4).

In this study, PCA showed noticeable variations of soil properties in the study site. Since these methods are of high accuracy and have different abilities, they could be used for habitat analysis and determination of effective ecological factors. Analyzing ecological data using ordination methods makes simpler understanding of the complex relationship between plants and environmental gradients. In addition, these methods prevent presence of ineffective factors and data complexity from affecting ecological models.

REFERENCES

Ajbilou, R., T. Maranon and M. Arroyo, 2006. Ecological and biogeographically analysis of Mediterranean forests of Northern Morocco. Acta Oecotogical, 29 (2): 104-113.

Austin, M.P. and I. Noy-Meir, 1971. The problem of non-linearity in ordination: Experiments with two-gradient models. J. Ecol., 59 (3): 763-773.

Coker, P.D., 2000. Vegetation Mapping: From Patch to Planet. Alexander, R. and A.C. Millington (Eds.). John Wiley and Sons Publication, pp: 135-158.

Cornelissen, J.H., 1996. An experimental comparison of leaf decomposition rates in a wide range of temperature plant species and types. J. Ecol., 4 (2): 573-582.

Corney, P.M., M.G. Leduc, S.M. Smart, K.J. Kirby, R.H. Bunce and R.G.H. Marrs, 2006. Relationship between the species composition of forest field-layer vegetation and environmental drivers assessed using a national scale survey. J. Ecol., 94 (3): 383-401.

Crowley, W., S.S.C. Harrison, M. Coroi and V.M. Sacre, 2003. An ecological assessment of the plant communities at Port Ban nature reserve in South-Western Ireland. Biology and Environmental: Proceeding of Royal Irish Academy, 1038 (2): 69-82.

Edwards, C.A., D.E. Reichk and A. Crossely, 1970. The Role of Soil Invertebrates in Turnover of Organic Matter and Nutrients. Springer-verlog, New York, pp: 147-172.

Ewald, J., 1999. Soziologie und standortbindung subalpiner fichtenwalder in den bayerischen Alpen. Tuexenia, 19 (1): 107-125.

Ewald, J., 2000. The influence of coniferous canopies on under story vegetation and soils in mountain forests of the Northern calcareous Alps. Applied Veg. Sci., 3 (2): 123-134.

Finzi, A.C., N.V. Breemen and C.D. Canham, 1998. Canopy tree-soil interaction within temperature forests: Species effects on carbon and nitrogen. Ecol. Applied, 8 (2): 440-446.

Fisher, R.F. and D. Binkley, 2000. Ecology and Management of Forest Soils. 3rd Edn. John Wiley and Sons, INC, pp: 489.

Goldsmith, F.B., 1973. The vegetation of exposed sea cliffs at south stack, Anglesey. The multivariate approach. J. Ecol., 61 (1): 787-818.

Grant, C.D. and W.A. Loneragan, 2001. The effects of burning on the under story composition of rehabilitee bauxite mines bin Western Australia: Community changes vegetation succession. For. Ecol. Manage., 145 (2): 255-277.

Hassanzad Navroodi, H., M. Namiranian and Gh. Zahedi Amiri, 2004. An Evaluation of relationship between quantitative and qualitative characteristics and site factors in the natural beech (*Fagus oreintalis*) stands in asalem. Iranian J. Nat. Res., 57 (2): 235-248 (In Persian).

Hedman, C.W., S.L. Grace and S.E. Ling, 2000. Vegetation composition and structure of southern coastal plain pine forests: An ecological comparison. For. Ecol. Manage., 134 (1): 233-247.

Hill, M.O., G.H. Bunece and M.W. Shaw, 1976. Indicator species analysis, a divisive polythetic method of classification and its application to a survey of native pine woods in Scotland. J. Ecol., 63 (3): 597-613.

Jongman, R.H., J.F. Break and F.R. Van Tongeren, 1995. Data Analysis in Community and Landscape Ecology. Center Fire Agricultural Publishing and Documentation, Wagering, pp: 52.

Lyon, J. and N. Gross, 2005. Patterns of plant diversity and plant-environmental relationships three riparian corridors. For. Ecol. Manage., 204 (2): 267-278.

Mahmoodi, J., G.H. Zahedi Amiri, E. Adeli and R. Rahmani, 2005. An Acquaintance with the relationship between plant ecological groups and the soil characteristics in a Kelarabad Plain Forests (In north of Iran). Iranian J. Nat. Res., 58 (2): 351-362 (In Persian).

Mc Cune, B. and M. Mefford, 1999. Multivariate Analysis of Ecological data Version 4.17. M.J.M Software. Glenden Beach, Oregon, USA, pp: 233.

Mesdaghi, M., 2001. Vegetation description and Analysis: A practical approach. Jehad Daneshgahi of Mashhad, Mashhad, pp: 161-179 (In Persian).

Mesdaghi, M., 2005. Plant Ecology. Jehad Daneshgahi of Mashhad, Mashhad, pp: 184. (In Persian).

Moghadam, M.R., 2000. Quantitative plant Ecology. Tehran University, Tehran, pp: 233-279 (In Persian).

Oland, J.M., J. Loidi Ander and G. Escudero, 1998. Relating variation in the under story of beech forests to ecological factors. Folia Geobot., 33 (3): 77-86.

Phillips, P.D., I. Yasman, T.E. Brash and P.R. Var Gardingen, 2002. Grouping tree species for analysis of forest data in Kalimantan (Indonesian Borneo). For. Ecol. Manage., 157 (3): 205-216.

Pourbabaei, H., 2004. Statistical Ecology. Guilan University, pp: 293-319 (In Persian).

Salehi, A., 2004. Investigation of physical and chemical soil properties variations in relation to trees composition and topographic factors in Nam-Khaneh district of educational-Experimental forest of Tehran University (Kheirood-Kenar forest). Ph.D Thesis, Tehran University, Tehran, pp: 187 (In Persian).

Salehi, A. and Gh. Zahedi Amiri, 2005. Study of physical and chemical soil properties variations using principal component analysis method in the forest, North of Iran. Caspian J. Environ. Sci., 3 (2): 131-137 (In Persian).

Salehi, A., M. Zarinkafsh, G.H. Zahedi Amiri and M.R. Marvi Mohajer, 2005. A study of soil physical and chemical properties in relation tree ecological groups in Nam-Khaneh district of Kheirod-Kenar forest. Iranian J. Nat. Res., 58 (3): 567-577 (In Persian).

Schoenholtz, S.H., H. Van Miegroet and J.A. Burger, 2000. A review of chemical and physical properties as indicators of forest soil quality: Challenges and properties. For. Ecol. Manage., 138 (2): 335-356.

Stendhal, J., S. Snall, T. Olsson and P. Holmgren, 2002. Influence of soil mineralogy and chemistry on site quality within geological regions in Sweden. For. Ecol. Manage., 170 (2): 75-88.

Taleshi, H., 2004. Phytosociology of lowland forests in eastern Nowshahr (North of Iran). M.Sc. Thesis Tarbiat Modares University, (In Persian).

Van-der-Marel, E., 1979. Transformation of cover-abundance values in phytosociology, its effects on community similarity. Vegetatio, 39 (1): 97-114.

Wilson, S.D., G. Pyatt, D.C. Malcolm and T. Connolly, 2001. The use of ground vegetation and humus type as indicators of soil nutrient regime for an ecological site classification of British forests. For. Ecol. Manage., 140 (1): 101-116.

Yau, Y., 1965. An approximate degrees of freedom solution to the multivariate Behrens-Fisher problem. Biometrics, 52 (3): 139-147.

Zahedi Amiri, G.H., 1998. Relation between ground vegetation and soil characteristics in a mixed hardwood stand. Ph.D. Thesis, University of Ghent, Begum Academic Press.

Zahedi Amiri, G.H. and S. Mohammadi Limayee, 2002. Relationship between plant ecological in herbal layer and forest stand factors (Case study: Neka Forest, Iran). Iranian J. Nat. Res., 55 (3): 341-353 (In Persian).