Quantifying the Rate of Environmental Factors Effect on *Astragalus* verus and *Agropyron trichophorum* Using Decision Support System and Multivariate Analysis of PCA

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Abstract. Vegetation cover over time and space is the result of interactions between vegetation cover and environmental factors. Changes occurred in range covers are caused by matrix dominance, one of the most important environmental factors. Decision support system (DSS) could be used for determining the rate and importance of each factor. Actually, in methods based on DSS, relations between input and output factors are identified. Up to now, various methods have been used in analyzing multivariate decision that includes binary comparison method that has been used in this study. This method has become one of the most commonly used methods of multivariate decision making and has been used for resolving unstructured issues in various human areas such as agriculture and natural sciences. In this study, nine sites were selected in west of Isfahan, Iran, then different vegetation cover and environmental factors were examined in each of these sites. By analyzing main components, effective factors and impact of range were identified, finally using analytical hierarchical pattern (AHP) model, the quantity of effective factors on Yellow *Astragalus* and grass sites was determined. The rate of limestone of soil and slope factor in Yellow *Astragalus* were 14.4 and 14.2%, respectively, which have the greatest effect and with regard to grass transmittal, Soil limestone and soil acidity influenced 20 and 13.2% of variation, respectively.

Key Words: Decision Support Systems (DSS), AHP, Multivariate analysis, *Astragalus verus*, *Agropyron trichophorum.*

Introduction

Vegetation cover over time and space is the result of interactions between vegetation cover and environmental factors. Changes occurred in vegetation cover are caused by matrix dominance, one of the most important environmental factors (Mesdaghi, 2002). In ecological examining of vegetation cover, stacking techniques are used. In stacking, sampling units are arranged based on similar traits (Species composition) and environmental controlling factors in relating to each other in 2 or 3 dimensional space coordinate axis in a way that their ecological similarities are emerged. Stacking methods are a part of gradient analysis that is usually used in two ways of direct and indirect gradient analysis (Jafari *et al*., 2003). Garcia *et al*. (2008) studying relationships of vegetation cover and physiographic factors in Mexico using two way indicator species analysis and stacking non-diagonal comparative analysis method, determined 8 plants communities based on slope, slope direction and height factors. In thisese methods, the rate of effect of each environmental factor on plant species is determined qualitatively and measured. For determining the rate and degree of importance of each factor, Dss[1] could be used. One of the newest methods is analytical hierarchy process (AHP) which is able to be combined with geographic information system (Garcia *et al*., 2008). In this method, a particular weight is assigned to each factor with respect to its direct importance rate in model. Multivariate decision analysis refers to a process in which inputs are changed and transformed in the form of consequences resulting from the decision. In methods based on DSS, the relations between input and output are determined (Ghodsi Pour, 2002). Multivariate decision making method includes a series of techniques (including weights and convergence analysis) which allows a range of criteria related to voting and weighting to be ranked by experts and interest groups (Parhizgar and agilavand, 2008). Up to now, various methods have been used in multivariate decision analysis including two-way comparative method that is used in these studies. This method has become one of the most commonly used methods of MCDM and is used for resolving unstructured issues in various human areas such as agriculture and natural sciences.

The main advantage of using AHP is that it helps decision-makers to break a complex issue to a hierarchical structure and then resolve it. Standard weights of decision-making and different items are obtained with respect to comparing only two elements in each stage (Ghodsi Pour, 2002). Patronu (1993) has conducted a research for determining ecological distribution and natural habitat in Toronto state in North of Italy using geographic information systems and multivariate analysis. He states that using geographic information systems and multivariate decision analysis would be useful for these kinds of studies.

Material and Methods

Study area is located in 65 km of Daran, Faridan County in Isfahan. The width extent of this area is 38578 Hectare with the geographical profile from 49° 50΄ 39״ to 50° 07΄27״ eastern longitude and from 32° 29΄ 52״ to 33° 15΄52״ northern latitude. The average of annual rainfall is about 485mm and the average of annual temperature is 9.8°C. Regarding to these conditions, the mentioned area climatically is under the category of clod steppe regions.

[1] - Decision support system

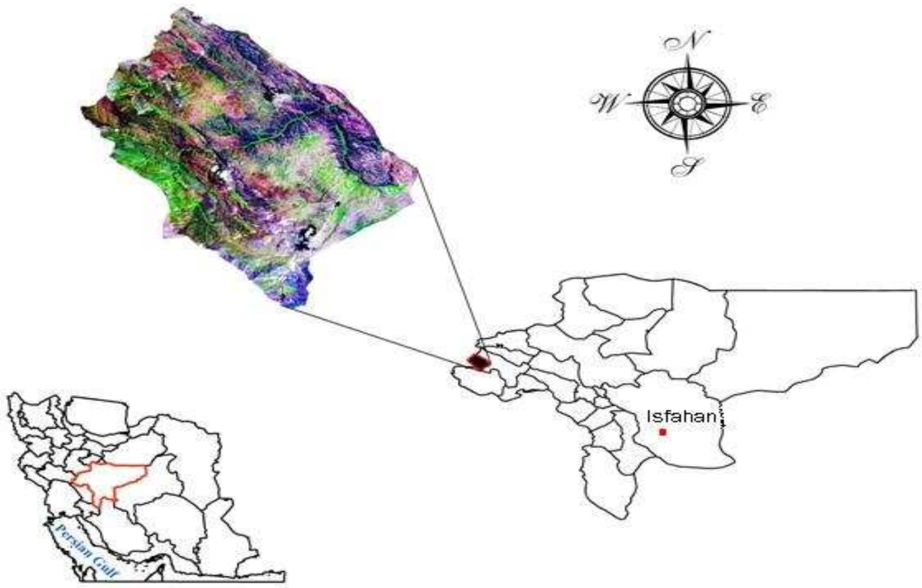

Fig. 1. Position of study area in Iran and Isfahan

Site Selection

This study had been conducted in nine range sites. The rangeland sites were determined based on vegetation cover map of the region and ecological. The 9-flods rangelands include good, moderate and poor sites (Grims and Hunter, 1990).

Analyzing Data

In this study, after preparing matrices and information related to different factors of ecological rangelands, initially principal component analysis (PCA) technique was used on environmental data for determining effective factors in studied species distribution. PCA was conducted using SPSS software. In Next stage, results of PCA were used and compiled in AHP model and finally the extent of impact of each environmental factor in studied species was determined. In this method, binary comparison was considered as input and relative weight as output. In binary comparison, the relative significances of factors are divided into 9 parts in a continuous scale (Malczewski, 2004) as shown in (Table 1). Coefficient vector shows the relative significance of factors. Determined ratios of factors are placed in comparison matrix. In this method, consistency ratio is used for preventing determination of random weights or errors, which might be occurred due to wrong comments of experts, or misunderstanding of database and entered to matrix. This ratio compares the extent of consistency of ratios and yields useful information to rater. Studies have shown that consistency ratio is accepted when it is less than 0.1 (CR<0.1) and in cases when it is more than 0.1, the relative significance of factors and their ratio should be re-evaluated (Asgharpour, 2005).

Table 1. Used scales in binary comparison scale in AHP method

Score	Verbal Scale	Explanation
1	2Scales have the equal significance.	The contribution of both of them in decision-making is identical.
2	Average significance of a scale compared to the other scale	Judgments and experiences prefer one scale to the other one.
3	Strong significance of one scale compared to the other scale	One scale is preferred strongly to the other one.
4	Very strong significance of one scale compared to the other scale	Preference of one scale to the other one is very strong.
5	Extreme significance of one scale compared to the other scale	Preference of one scale to the other one is extreme.
6	Moderate amounts	Creating consistency between two judgments.

Binary comparison of variables can be done in 3 following ways

1) Using expert knowledge: In this way, by using the experience and knowledge of experts in desired application, and considering features of study area, proper factors are determined and compared. The advantages of this method are simplicity and being documented but this method has some drawbacks such as probability of expert's mistake in weight determining and the problem of standardization of their subjective measurement units.
2) Using data knowledge: data knowledge relies on existing information about responses of problem. In data knowledge, by using existing responses in site selection problem and calculating the extent of dependence of each factor on response, the weight of each factor can be determined. In this method, the probability of error is less but accuracy of its operation depends on the extent of accuracy and precision of existing initial answer.
3) Using expert knowledge and data knowledge together: in this way, with regard to the results of knowledge and experiences of experts and using existing information, variables are compared. First, comparisons are calculated by expert and data knowledge separately, and then appropriate weight is determined by comparing acquired amounts. In conclusion, the probability of error reduces and weights would approach the reality more.

AHP approaches include the following basic stages

1) Defining the unstructured problem, stating the aims and consequences clearly.
2) Breaking a complex problem to a hierarchical structure with decision elements (Scales and strategies).
3) By comparative scales, conducting a pair ways among scales.
4) Using Eigen values of comparative matrix for estimating relative weights of decision elements.
5) Checking consistency of comparisons to ensure that decision maker's judgments are coherent and accurate.
6) The basis of weight determination is binary comparison. A set of weights determination that shows the relative significance of factors equals to one (Mesdaghi, 2002).

In this model 7 stages were completed and implemented as follows:

1) In first stage, the most important factors (effective factors) in plant species distribution should be determined for this aim PCA method can be used and finally, effective factors of determining site of 2 studied species are identified.
2) The purpose of this stage is to determine weight for each scale for which AHP model and binary

comparison have been used. Binary comparison has been conducted by a scale, which was designed from

3) that using scale from 1.9 to 9 enables decision makers to do comparisons properly, so using (Table 1) in comparative voting has become a standard. Pair wises have been recorded in a k x k matrix. It is noticeable that pair wises matrix in AHP is an inverse matrix; it means if the preference of scale 1 to 2 is 5, the preference of 2 to 1 is 1.5. In every mentioned situation, comparison amount shows judgment of planner on relative significance of one scale than other one. Regarding to the matter that scales are shown in two ways (numbers from 1 to 9 and reverse numbers 9 to 1), if the amount of comparison is more than one, it means that the measure which is in row has more relative significance than the measure in Column.
4) Formation of binary comparison matrix: In this study, expert and data knowledge method is used for formation of binary comparison matrix due to the nature of environmental and species data, goal and also existence of a strong database (Grims, 1990).In this way, after determining expert ideas, geometric mean was used for identifying more important factors (because comparison matrix is inverse, it justifies using geometric ean), then for more accurate evaluation of weights, expert ideas with the help of first stage analysis were corrected and revised.
5) In this stage, results of pair wises were compiled in Expert Choice software and theweight of each scale was determined by this software. EC is powerful software in implementing multivariate decision analysis process, which is used in more than 20 countries (Malczewski, 2004).This software has many abilities in addition to designing hierarchical diagram, it is also able to

identical preference to full preference. Experience has shown

make decision, design question, determine preference and priorities, calculate final weight and analyze decision-making sensitivity to changes in problem parameters (Ghodsi Pour, 2002).

6) Significance of AHP, in addition to combining different levels of hierarchy of decision and considering various factors, is in calculation of consistency ratio (C.R)[2]. Consistency ratio is a mechanism that determines the consistency of comparison; it shows how much we can trust the resulting priorities. If consistency ratio is more than 0.1, compiled numbers in pair comparisons of table should be reviewed and modified (Malczewski, 2008).

Conclusion and Discussion

A) Principal component Analysis (PCA)

Results of PCA for 9 (9-fold) environmental variables are shown in (Tables 2 and 3). First, second and third principals justify 24.6, 21.6, and 19.65 percent of vegetation cover changes, respectively.

2 -Consistency Ratio

Table 2. Result of PCA between the main environmental factors

Variable	1	2	3	4	5	6
PRECIP	0.2709	0.1953	0.0094	0.3361	0.1308	0.113
AMAXT	-0.3355	0.1587	-0.0272	-0.1546	0.2098	0.3059
AMINT	-0.3029	0.0172	0.1395	-0.259	0.2898	-0.144
GRAV	0.0022	0.2852	0.0725	-0.1178	-0.3121	-0.515
EC	-0.0573	0.411	0.0886	-0.1702	-0.0401	0.2437
SP	-0.203	-0.1603	0.1326	0.0407	-0.4839	0.1301
O.M	0.2715	0.2201	0.2412	0.0832	0.0531	-0.0637
CACO3	0.1136	-0.0925	-0.3936	-0.0593	-0.2773	0.1916
CLAY	0.0203	-0.3947	0.2554	0.041	0.0175	0.0157
SILT	-0.3311	0.1738	-0.133	0.1414	-0.2205	-0.1414
SAND	0.3093	0.1912	-0.1051	-0.18	0.2019	0.1236
N	0.0005	0.2453	0.377	-0.1409	-0.079	0.254

Table 3. Environmental factors correlation with principal components

Axis	Eigen Values	Variance	Cumulative variance
1	5.17	24.65	24.65
2	4.54	21.65	46.30
3	4.07	19.41	65.71
4	2.81	13.38	79.10
5	2.31	11.00	90.10
6	1.03	4.90	95.01
7	0.61	2.90	97.91
8	0.43	2.08	100.00

With respect to correlation variable table of components, first principal component involves features such as Tmax, Tmin, Silt, sand, Height and second component with EC, Clay and phosphorus have a high correlation and third component has a strong correlation with lime and Nitrogen (Table 3). Regarding the rate of variance percentage, we conclude that in study area, the most important factors of vegetation type separation are Tmax, Tmin, Soil tissue, rate of altitude (from sea) and EC variables, phosphorus, lime and nitrogen are effective factors of site separator.

B) Determining Rate of Effective Factors

As mentioned, AHP model and Export Choice software were used for quantifying the rate of each environmental factor which resultant outputs are as follows.

As we see in diagrams, lime factor affects (CACO3) Yellow *Astragalus* distribution 14.8% and then slope direction, pebble percent (SP), rainfall factors, with effect rate of 14.2, 13.7 and 11.7 percent respectively have the highest impact percent on Yellow *Astragalus* distribution in study area. For grass Lime soil, acidity (pH) and clay factors affect 20.1, 13.2, and 11.8 percents, respectively.

Consistency Ratio (C.R): Consistency coefficient of comparison matrix of *Agropyron trichophorum* is 0.07 and comparisons matrix of *Astragalus verus* is 0.09. Regarding to this results the rate should be less than or equal to 0.1, in consistent judgment, it could be accepted. It is noticeable that all related calculations including calculating factor weights and calculating consistency coefficient were conducted by using Expert Choice software and finally weight of effective scales were obtained. The resultant outputs of EC Software for study species are shown in (Figs. 2 and 3).

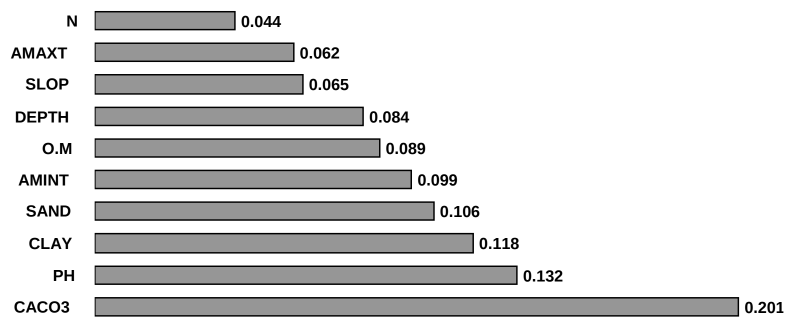

Fig. 2. Factors affecting species distribution, *Agropyron Trichophorum*

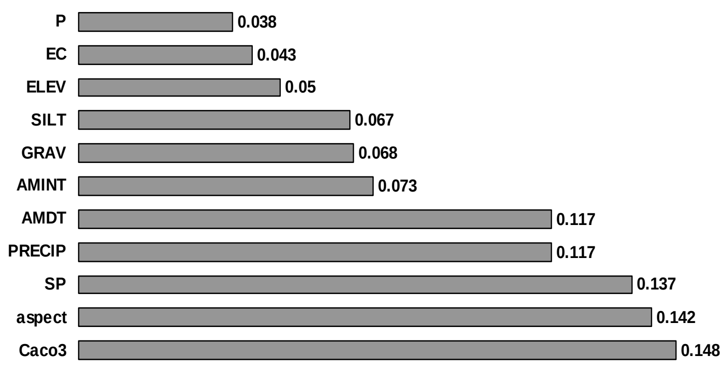

Fig. 3. Factors affecting species distribution, *Yellow Astragalus*

Conclusion

In this study, statistical ecological methods and specially PCA were used for analyzing ecological data. Generally, environmental and species data stacking and other used methods in this study were used for serving to AHP and its more accurate implementation and high efficiency of these methods was appeared clearly. Generally, in site information models and particularly in AHP model, there will be more variables and the less and more logical informational layers, the more accurate results and more real output of model. This matter is so important that researchers state that if there are so many variables (more than 12 or 13), practically efficiency of AHP will reduce; so in this study, statically and stacking methods were used in order to determine unnecessary factors and variables and remove them from model. From all studied environmental factors, number of effective factors on grass site was 10.0. If one decided to use all factors, because number of variables was more than standard number and the resultant weights could not be trustable, so there would be errors in resultant priorities. Thus, stacking analysis due to great accuracy and various abilities can be used in analyzing and recognizing effective ecological factors on plant species distribution and with this action, understanding complex relations between plant and environment become easier, therefore it prevents the complexity of information and presence of less effect variables in model and it identifies the most important variables. In this study, high application of stacking and statistical studies was well recognized for preparation of model input. Actually, in AHP, attacking results can be used in a simple way because comparisons are conducted two by two and independently from other variables, so it constitutes input matrix. For determining importance rate of one factor, we can put together outputs, different results of statically analysis and even ideas of different persons and we can do a logical comparison. As final conclusion of this paragraph and this study, it is stated that in ecological studies and other similar modeling studies, if researcher doesn't have an access to a good data base, his model would not be accurate enough and the researcher would deviate so much in judgments.

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