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Application of Euclid distance-based fuzzy similarity priority ratio method to quantitative decision-makings concerning seed introduction of lawn grass

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ABSTRACT

In the light of the seed introduction similarity theory, the paper applies a kind of Euclid distance-based fuzzy similarity priority ratio method to the comparison of ecological environment similarity between original place and introduced place of lawn grass. The results of comparison can well manifest the similarity between original place and introduced place in quantity, thus offering the quantitative basis to decision-makings concerning the fuzzy and gradient seed introduction of lawn grass.

KEYWORDS

Euclid distance; Fuzzy similarity priority ratio method; Seed introduction of lawn grass.

INTRODUCTION

In recent years, cities have been going through the common development of economy, culture, and environment. Environment is the key issue of urban development, and lawn cultivation constitutes an important part of urban environmental development. Seed introduction, as the basic material for lawn cultivation, has always been the focus of people's attention. How to select the suitable grass seed at a specific site is crucial for the success of lawn cultivation. Currently, the seed introduction is generally based on the similarity theory. This means that in grass seed introduction, if the environmental condition required by a kind of grass is similar to that of the original place, the possibility of successful introduction will be much higher. Based on the principle, the paper employs Euclid distance to calculate ecological differences of original place and introduced place, and ranks their similarities via the fuzzy similarity priority ratio method according to the results of calculation. The higher the similarities are, the higher the possibility of successful introduction is. Seed introduction of lawn grass can be quantified through the method, thus making decision-makings concerning seed introduction more scientific and reliable.

FUZZY SIMILARITY PRIORITY RATIO METHOD

Fuzzy similarity priority ratio method[1], a form of fuzzy measurement, compares a pair of samples with the fixed sample so as to determine which one is more similar to the fixed sample, and finally to select the more similar one. This method can be used to comprehensively compare and evaluate environmental conditions of original place and introduced place of lawn grass[2].

Similarity priority ratio

When fuzzy similarity priority ratio method is employed to compare original place and introduced places of lawn grass, original place is taken as the fixed sample, denoted by x_k, and introduced places are taken as the samples to be compared, denoted by x_i and $x_j (i, j = 1,2,\cdots,n)$. Samples x_i and x_j are compared with the fixed sample x_k, and their similarity priority ratio r_{ij} should meet the following requirements:

(1) If r_{ij} is between [0.5, 1.0], x_i enjoys the priority over x_j.

(2) If r_{ij} is between [0.5, 1.0], x_j enjoys the priority over x_i.

(3) There are three possibilities for limit values in the above two zones:

If $r_{ij} = 1$, x_i enjoys the apparent priority over x_j.

If $r_{ij} = 0$, x_j enjoys the apparent priority over x_i.

If $r_{ij} = 0.5$, x_i enjoys the same priority with x_j, so it is impossible to determine the priority.

Construct fuzzy correlation matrix on the basis of Euclid Distance

Euclid Distance, also called Euclid metric, is a generally adopted distance definition, indicating the true distance between two points within the m-dimensional space. Euclid distance can also be used to comprehensively measure multi-dimensional information data. Therefore, it is regarded as r_{ij} in the similarity priority ratio analysis of this paper. Samples x_i and x_j are compared with the fixed sample x_k, and similarity priority ratio of Euclid distance can be defined as:

$$r_{ij} = \frac{d_{ik}}{\left(d_{ik} + d_{jk}\right)}, \quad r_{ji} = 1 - r_{ij} \quad (1)$$

Where d_{ik} describes the difference between x_i and x_k under the m-dimensional space, and its equation is as follows:

$$d_{ik} = \sqrt{\sum_{s=1}^{m} \left(x_{is} - x_{ks}\right)^2} \quad (2)$$

d_{jk} describes the difference between x_j and x_k under the m-dimensional space, and its equation is the same with that of d_{jk}.

Compare the given sample set $X = \{x_1, x_2, \cdots, x_n\}$ with the fixed sample x_k, namely calculating the similarity priority ratio between any x_i $(i = 1, 2, \cdots, n)$ and x_k so as to set up the fuzzy correlation matrix with r_{ij} as the matrix element:

$$R = \begin{cases} r_{ij} & i \neq j \\ 1 & i = j \end{cases} (i, j = 1, 2, \cdots, n) \quad (3)$$

Determination of similarity alignment

Clustering analysis method [2] is employed in the paper to select similarity alignment. Clustering analysis is to, on the basis of the constructed fuzzy similarity priority ratio matrix $R = (r_{ij})$, determine a λ and cut matrix R so as to obtain a simplified matrix. The so-called cutting is to select a figure λ within the (0, 1) scope, compare the element r_{ij} with λ in the matrix R, and accordingly obtain the simplified matrix element r'_{ij}. The simplification rule is:

$$\begin{cases} r'_{ij} = 1 & r_{ij} > \lambda \\ r'_{ij} = 0 & r_{ij} < \lambda \end{cases} \quad (4)$$

Finally, we obtain a matrix R_λ composed of only 0, 1. If there is no such a row in R_λ that all its elements are 1 (except for diagonal element), reduce the value of λ until at least one row contains 1 completely (except for diagonal element). The concrete method is:

(1) Reduce the value of λ, when $\lambda = \lambda_1$, elements of one row at least in R_λ equal to 1 (except for diagonal element). Write down the serial numbers of the rows, and obtain the first batch of objects whose priority is 1.

(2) Delete the line and row from R that correspond with the first batch of objects, and construct the new matrix R^1. Select $\lambda = \lambda_2$, and obtain the second batch of objects whose priority is 2 through the cutting method.

(3) Delete the line and row from R^1 that correspond with the second batch of objects, and construct the new matrix R^2. Repeat the above procedures until obtaining the serial numbers of all objects[4-6].

APPLICATION EXAMPLES

It is planned to introduce Zoysia matrella from Fukuoka, Japan into our country's Hefei, Changsha, Guilin, Wenzhou, and Chengdu. Fuzzy similarity priority ratio method is used to compare and analyze average air temperature, annual precipitation, annual sunshine duration, annual extreme lowest air temperature, and monthly average air temperature, from 1951-1972, of the original place Fukuoka and the five introduced places listed in Table 1 in a bid to determine the place most suitable for the introduction and cultivation of Zoysia matrella.

X_1, X_2, X_3, X_4, and X_5 in the table indicate the introduced places Hefei, Changsha, Guilin, Wenzhou, and Chengdu, and X_6 indicates the original place Fukuoka. Annual average temperature S_1, annual precipitation S_2, annual sunshine duration S_3, annual extreme lowest temperature S_4, and monthly average temperature S_5 are taken as similarity factors[7].

Table 1 : Winter Climate Data (1951-1972)

	X₁	**X₂**	**X₃**	**X₄**	**X₅**	**X₆**
S_1(℃)	0	0.48	1	0.71	0.19	0.16
S_2(mm)	0	0.18	1	0.81	0	0.58
S_3(h)	1.0	0.50	0.43	0.63	0	0.78
S_4(℃)	0	0.69	0.79	1	0.99	0.77
S_5(℃)	0	0.46	1	0.95	0.68	0.73

$$x_{is}^e = \frac{x_{is} - x_{s\min}}{x_{s\max} - x_{s\min}} (i = 1, 2, \cdots, 5; s = 1, 2, \cdots, 5) \quad (5)$$

i, s in the equation express the serial numbers of the introduced places and similarity factor respectively. $x_{s\max}$ and $x_{s\min}$ express the maximum value and minimum value of the sth factor in the sample set respectively. If $x_{is} = x_{s\max}$, $x_{is}^{e} = 1$; if $x_{is} = x_{s\min}$, $x_{is}^{e} = 0$; therefore, $x_{is}^{e} \in [0,1]$. The equation above can be used to normalize data in Table 1 so as to obtain the normalized winter climate indexes shown as Table 2.

Table 2 Normalized Winter Climate Data

	X_1	X_2	X_3	X_4	X_5	X_6
S_1(℃)	15.7	17.2	18.8	17.9	16.3	16.2
S_2(mm)	970	1129	1874	1698	976	1492
S_3(h)	22.09	1726	1709	1848	1239	2000
S_4(℃)	- 20.6	- 9.5	- 4.9	- 4.5	- 4.6	- 8.2

(2) Euclid distance is used to calculate the difference between the candidate samples and the fixed sample

Equation (2) is used to calculate Euclid distance between the candidate sample X_i and the fixed sample X_6, and $d_{16} = 0.554$, $d_{26} = 0.290$, $d_{36} = 0.4472$, $d_{46} = 0.31$ and $d_{56} = 0.448$.

(3) Determination of fuzzy similarity priority ratio matrix

According to Equation (1), fuzzy priority ratio matrix $R = (r_{ij})$ is determined as:

$$R = \begin{bmatrix} 1 & 0.334 & 0.460 & 0.359 & 0.447 \\ 0.656 & 1 & 0.619 & 0.517 & 0.607 \\ 0.540 & 0.381 & 1 & 0.396 & 0.487 \\ 0.641 & 0.483 & 0.604 & 1 & 0.591 \\ 0.563 & 0.393 & 0.513 & 0.409 & 1 \end{bmatrix}$$

(4) Determine the similarity alignment according to λ value λ is between (0, 1). Determine a λ value, and cut matrix R with equation (4). If the cut matrix contains at least a row whose elements are completely 1 (except for diagonal element), number the row, and delete the corresponding line and row in matrix R; if not, reduce the value of λ until at least one row in the simplified matrix contains 1 completely (except for diagonal element).

When $\lambda = 0.517$, cut matrix R through Equation (4) and form the simplified matrix R_{λ}^{1}:

$$R_{\lambda}^{1} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Elements in the second row of R_{λ}^{1} are 1 completely, so the row is ranked 1. Delete the second row and the second line in matrix R to form a new matrix R^1;

$$R^1 = \begin{bmatrix} 1 & 0.460 & 0.359 & 0.447 \\ 0.540 & 1 & 0.396 & 0.487 \\ 0.641 & 0.604 & 1 & 0.591 \\ 0.563 & 0.513 & 0.409 & 1 \end{bmatrix}$$

When $\lambda = 0.483$, cut R^1 to form the simplified matrix. Elements in the fourth row of the matrix are 1 completely, the row is ranked 2; similarly, the fifth row is ranked 4, the third row ranked 4, and the first row ranked 5. Therefore, we can obtain the similarity alignment $X_2 > X_4 > X_5 > X_3 > X_1$, namely that the possibility of successful introduction of Zoysia matrella is Changsha >Wenzhou >Chengdu >Guilin >Hefei.

CONCLUSIONS

The paper analyzes and calculates the environmental similarity factors of the five cities to introduce lawn grass and the original city Fukuoka through the Euclid distance-based fuzzy similarity priority ratio method, and concludes that among the five cities, Changsha has the highest similarity while Hefei has the lowest similarity. Therefore, Changsha is the most likely to introduce Zoysia matrella successfully. In the whole comparison process of environmental factors, the paper employs the fuzzy similarity priority ratio method to compare data quantitatively, and the conclusion is highly scientific and reliable. Meanwhile, this also makes it possible to decide seed introduction of lawn grass in a quantitative way.

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